TIPS ON SPOTTING SOUTHERN STAR CLUSTERS

Astronomy®

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SUPERNOVA BLAST

Eta Carinae Heats Up

Prospecting for Lunar Ice and Iron

How You Can Become a CCD Image-maker

Man on the Moon, Eugene Shoemaker

Now two ETX apertures!
ETX-90EC — $595
ETX-125EC — $895

Now you can buy the revolutionary Meade ETX® — the largest selling modern telescope in the world — in either of two apertures, 3.5" or 5". Both models include the very latest in microprocessor-controlled capability.

New Fork Mount Designs with Standard-Equipment Dual-Axis Drive Systems: Each with high-torque DC motors on both telescope axes, permitting electronic operation from the standard-equipment plug-in hand controller.

Pushbutton Electronic Hand Controller: Use at any of four dual-axis speeds: 8x for image centering at high power; 32x for image centering at lower power or for pushbutton object-tracking in the altazimuth mode; 0.75°/sec for image centering in the viewfinder or for terrestrial tracking; 5°/sec for fast slewing across the sky.

Cordless Operation: The dual-axis drive system operates for more than 40 hours from eight (user-supplied) AA batteries which store neatly inside the drive base.

Optional Autostar™ Capability: Plug in the optional Meade Autostar computer controller *(see facing page)* for LX200-type operation, including automatic GO TO capability to more than 14,000 celestial objects.

Plus the features that created the ETX revolution:

Maksutov-Cassegrain Optical Systems: Manufactured at the Meade Irvine, California facility, ETX diffraction-limited optics produce images so high in contrast, brightness, and resolution that ETX telescopes often outperform other telescopes of larger apertures.

Flip-Mirror System: Flip the internal optical flat mirror "up" for 90° observing; flip the mirror "down" for terrestrial observing with the optional #932 45° Erecting Prism or for photography with the optional #64 Photo Adapter.

SPECIFICATIONS: ETX-90EC and ETX-125EC Astro Telescopes — Each includes Maksutov-Cassegrain optical tube assembly (D = 90mm, F = 1250mm, f/13.8 *or* D = 127mm, F = 1900mm, f/15) with EMC super multi-coatings; internal flip-mirror system for either straight-through or 90° observing position; fork mount with electric slow-motion controls, setting circles and locks on both axes; electronic control panel; 4-speed (8x, 32x, 0.75°/sec, 5°/sec) dual-axis motor drive system with hand controller; sidereal-rate tracking in equatorial mode with optional table tripod or deluxe field tripod; internal battery compartment accepting eight (user-supplied) AA-size batteries; 8 x 21mm erect-image (ETX-90EC) *or* 8 x 25mm right-angle (ETX-125EC) viewfinder; Series 4000 Super Plössl 26mm eyepiece (1.25"); instructions. **ETX-90EC — $595** (+ $20 packing & shipping in the 48 states); **ETX-125EC — $895** (+ $30 P & S).

MEADE
ETX-90EC • ETX-125EC
NEW!
COMPUTER CONTROL
MEADE

Meade **ETX-90EC: $595** and **ETX-125EC: $895.** Each complete as shown, with electronic hand controller; plus packing and shipping.

OPTIONAL SYSTEMS*

#497 Autostar Computer Controller (90, 125)	$149
#880 Equatorial Table Tripod (90)	29.95
#881 Equatorial Table Tripod (125)	59.95
#883 Deluxe Field Tripod (90, 125)	199.95
#825 8 x 25mm Right-Angle Viewfinder (90)	49.95
#774 Hard Carry Case (90)	99.95
#775 Hard Carry Case (125)	149.95
#932 45° Erecting Prism (90, 125)	49.95
#64 Photo Adapter (90, 125)	34.95
Electric Focuser #1244 (90) *or* #1247 (125)	119.95

**see the Meade accessory ad in this issue.*

AUTHORIZED MAIL-ORDER DEALERS

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Orders: 800-422-7876; Info.: 405-364-0858.

FOCUS CAMERA, Brooklyn, NY.
Orders: 800-221-0828; Info.: 718-436-6262.

LUMICON, Livermore, CA.
Orders: 800-767-9576; Info.: 925-447-9570.

OCEANSIDE PHOTO & TELESCOPE, Oceanside, CA.
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POCONO MOUNTAIN OPTICS, Moscow, PA.
Orders: 800-569-4323; Info.: 570-842-1500.

RIVERS CAMERA, Dover, NH.
Orders: 800-245-7963; Info.: 603-742-4888.

SHUTAN CAMERA & VIDEO, Chicago, IL.
Orders & Info.: 800-621-2248; IL: 312-332-2000.

EFSTONSCIENCE, Toronto, Ontario, Canada
Orders & Information: 416-787-4581.

KHAN SCOPE CENTRE, Toronto, Ontario, Canada
Orders & Information: 416-783-4140.

Add the Meade Autostar™ computer to your ETX-90EC or ETX-125EC for automatic GO TO object location ...only *$149!*

ETX AUTOSTAR
RA = 08:04.6
Dec = +36°38
MEADE
ENTER
MODE
GO TO
1
2
3
4
5
6
7
8
9
0
?

The Meade #497 Autostar Computer Controller *(shown actual size)* plugs in to the control panel of the Meade ETX-90EC or ETX-125EC telescope and permits LX200-type automatic object location from a 14,000-object database, a database that includes virtually every astronomical object visible with the ETX-90EC or ETX-125EC — **$149.**

Plug the #497 Autostar Computer Controller into your ETX-90EC or ETX-125EC and you're ready for an incredible array of LX200-type capabilities:

Automatic dual-axis GO TO function at 5°/sec to any of more than 14,000 database objects, including deep-space objects (galaxies, diffuse nebulae, planetary nebulae, star clusters — the best objects from the IC, NGC and Caldwell catalogs, as well as all 110 Messier objects); 900 stars (double stars, variable stars, SAO stars); the 8 major planets from Mercury to Pluto; 26 of the brightest asteroids; 15 periodic comets; 50 earth-orbiting satellites; plus user-defined objects and the centroids of all 88 constellations. Select any of these objects, press ***GO TO*** and the telescope automatically slews to the object, placing it in the telescopic field.

Automatic GO TO function to *any* object of known R.A. and Dec.

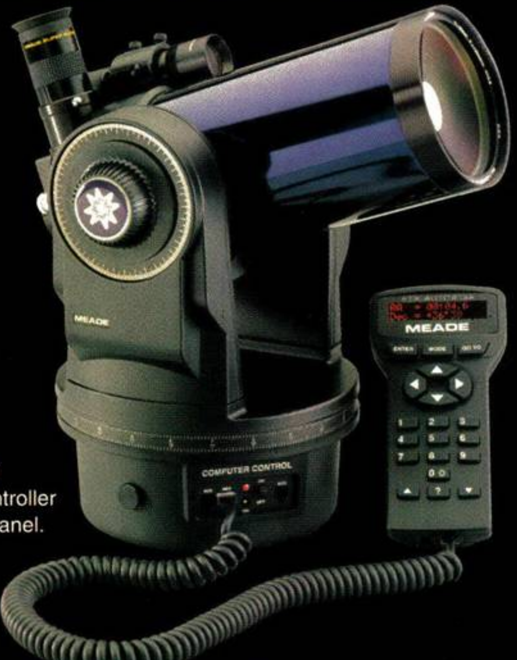
Digital readouts of telescope position (continuously in R.A. and Dec.), menu options, glossary, and utility functions.

Precise sidereal-rate tracking in either altazimuth or equatorial modes. For altazimuth tracking, set the telescope on its drive base and perform a quick, easy alignment.

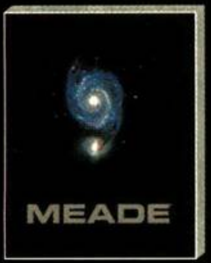
9-Speed Dual-Axis Operation: Pushbutton operation of the telescope on both axes, simultaneously, at any speed from 2x sidereal to 5°/sec.

RS-232 Serial Port: For operation of the telescope through a personal computer, using Meade Epoch 2000® sky software or other sky software using the LX200 protocol.

Plus: over 20 other menu options, including guided tours, major event menus, user-defined terrestrial objects, and much more.



(right) **Meade ETX-90EC,** shown with optional #497 Autostar Computer Controller plugged into the telescope's control panel.



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Patents pending on ETX-90EC, ETX-125EC, and Autostar.

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From *The Glorious Constellations*, © 1991; Harry N. Abrams, Inc.

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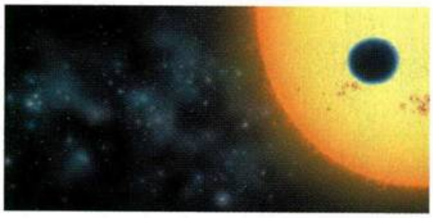

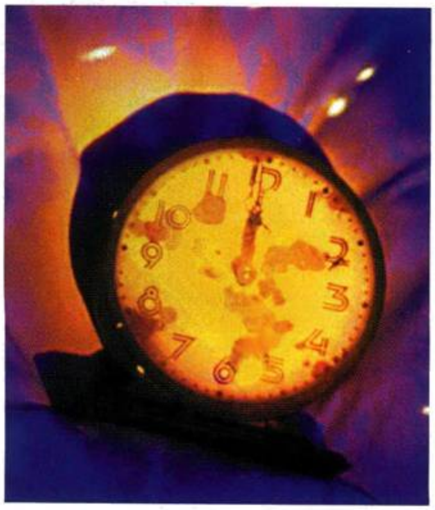

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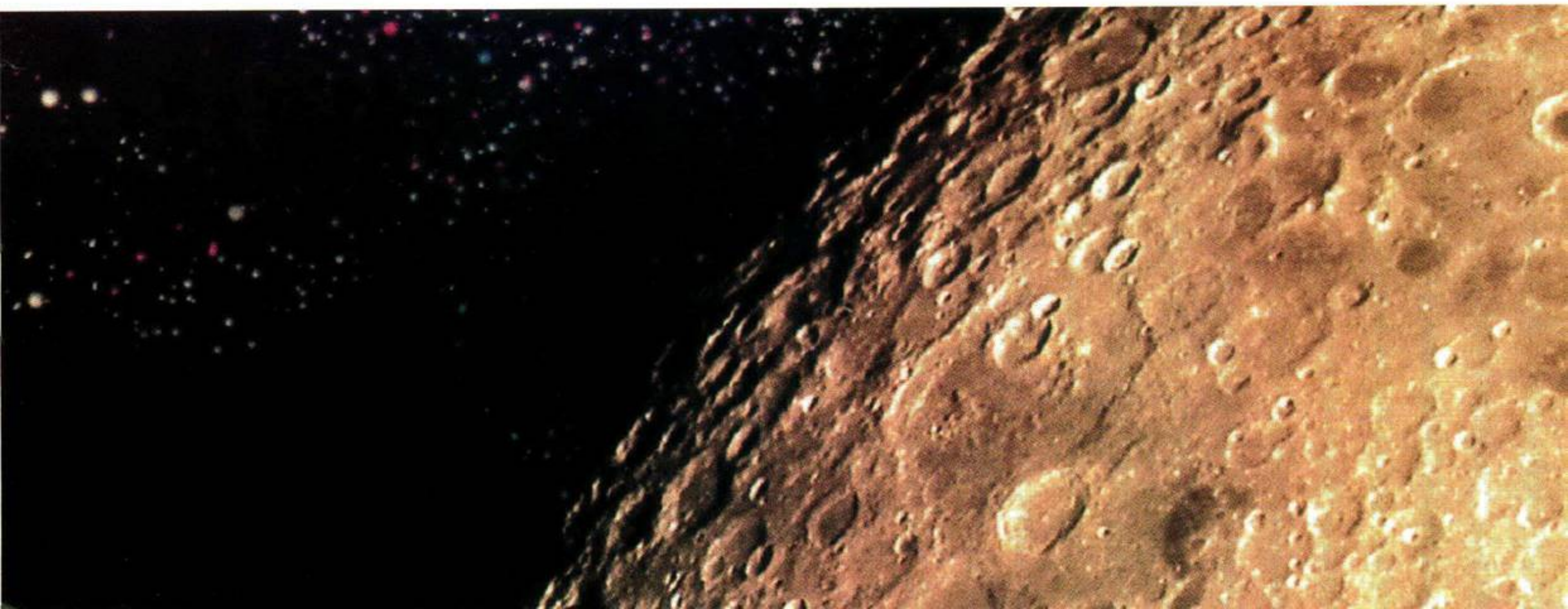

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BEHIND THE SCENES

BY BONNIE BILYEU GORDON

Taking Astronomy Public

I recently met with 40 high-school teachers in Illinois who were interested enough in astronomy to sign up for a training program that required several weekends of extra work. They were learning how to use telescopes through the auspices of the Adler Planetarium in Chicago and the Yerkes Observatory near Lake Geneva, Wisconsin. Several course participants said they used *Astronomy* magazine in their classrooms.

Carol Ryback

I was surprised to find that they were bringing personal copies of the magazine to class, that none of them knew about our classroom discounts. We sell *Astronomy* for classroom use at half price, and we sell short-term subscriptions that coincide with the academic year. So you only have to buy what you need, but you must order at least 15 copies. If you would like to know more, call 1-800-533-6644 and ask for the school discount.

We have other plans in the works to encourage astronomical interest — public star parties and astronomy workshops. In the months ahead, we will offer a few ideas on how you can become a volunteer astronomy teacher in local schools. We also will take another look at what astronomy clubs can do to enhance activities and boost membership. The more active you become in sharing your interest, the more new folks will find themselves at a telescope looking for the first time at Saturn.

One of the people who will help *Astronomy* magazine convert interest to activity is Carol Ryback, our newest associate editor. Carol will be acquiring and editing stories for the magazine. She is replacing Tracy Staedter, who left us to become managing editor of *Scientific American Explorations*, a new science magazine for families produced in Boston.

Carol has been working in publishing for eight years, following a career change that took her from medicine to writing. She has been the editor of a national magazine called *Reunions* and written for a wide array of publications. Her background in science writing is excellent, her enthusiasm for observing is remarkable, and she is particularly intrigued by the energetic interest of amateur astronomers. Carol, a Milwaukee, Wisconsin, native, loves the outdoors, both day and night, and she is an avid skier, scuba diver, and dog lover.

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$795
(+ $65 packing and shipping in the 48 states)
(shown with optional #1702 Drive System)
Model 203SC/500:
8" f/10 Schmidt-Cassegrain Telescope
$895
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Model 102ACHR/300:
4" f/9 Achromatic Refracting Telescope
$595
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4" f/9 Achromatic Refracting Telescope
$695
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MEADE 203/SC EMC

LXD 300

Now you can buy a Meade® 8" f/10 Schmidt-Cassegrain Telescope, complete with LXD 300 equatorial mount, rigid full-length aluminum tripod, and accessories for only $795! Or a Meade 4" f/9 Achromatic Refractor, complete, for only $595!

Choose either the Meade 203SC/300, with the exact same optical tube assembly as more expensive Meade 8" Schmidt-Cassegrains, or the Model 102ACHR/300 with its exquisite 4" Meade air-spaced achromatic lens. Both telescopes are equipped with the high-performance Meade LXD 300 equatorial mount with dual-axis aluminum worm gears.

SPECIFICATIONS: Models 203SC/300 and 102ACHR/300 — Each telescope includes 8" f/10 Schmidt-Cassegrain *or* 4" f/9 Achromatic Refractor optical tube assembly with EMC super multi-coatings; LXD 300 equatorial mount with aluminum worm gears, micrometric manual slow-motion controls, and setting circles on both axes; manual control for azimuth alignment; elevation control and scale for polar alignment at latitudes from 15° to 50°; adjustable full-length aluminum tripod with bubble level and accessory shelf; 6 x 30mm achromatic viewfinder; eyepiece-holder (1.25"); #918A diagonal prism (1.25"); Series 4000 Super Plössl 26mm eyepiece (203SC) *or* Series 3000 Plössl 25mm eyepiece (102ACHR); provision for addition of optional #812 Polar Alignment Finder; operating instructions. **8" — $795** (+ $65 P & S); **4" — $595** (+ $55 P & S); **#535 R.A. Motor Drive System**...**$99; #812 Polar Alignment Finder**...**$49.**

LXD 500

For even broader capability, use the Meade® high-precision LXD 500 equatorial mounting, 20% larger and with dual-axis bronze worm gears — the finest equatorial mounting available in its price class.

SPECIFICATIONS: Models 203SC/500 and 102ACHR/500— Each telescope includes 8" f/10 Schmidt-Cassegrain *or* 4" f/9 Achromatic Refractor optical tube assembly with EMC super multi-coatings; LXD 500 equatorial mount with oversize bearings, high-precision bronze worm gears, micrometric manual slow-motion controls, and setting circles on both axes; manual control for azimuth alignment; elevation control and scale for polar alignment at latitudes from 15° to 60°; adjustable full-length aluminum tripod with bubble level and accessory shelf; 6 x 30mm achromatic viewfinder; eyepiece-holder (1.25"); #918A diagonal prism (1.25"); Series 4000 Super Plössl 26mm eyepiece (203SC) *or* Series 3000 Plössl 25mm eyepiece (102ACHR); provision for addition of optional #812 Polar Alignment Finder; operating instructions **8" — $895** (+ $65 P & S); **4" — $695** (+ $55 P & S); **#1701 R.A. Motor Drive System** with 4-speed controller...**$145; #1702 Dual-Axis Drive System** with 4-speed controller...**$195**; **#812 Polar Alignment Finder**...**$49.**

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MEADE LX50

Advanced technology at the most affordable prices *ever.*

- **Battery-Powered, Completely Cordless Operation!** Meade LX50 models operate for more than 50 hours from six AA-size batteries inserted through the telescope's control panel.
- **Standard-Equipment Declination Motor and Hand Controller:** Plug the hand controller into the LX50 control panel and you're ready for dual-axis drive capability at any of 4 photo-guide or microslew speeds: 2x, 8x, 16x, or 32x, plus quartz-controlled sidereal-rate tracking in R.A.
- **Multi-Function Control Panel:** Includes connectors for CCD autoguiders; for the standard-equipment Declination motor; and for the optional Magellan II Computer-Corrector *(below)*.
- **Super Multi-Coated Optics:** The exact same EMC super multi-coated optical tube assemblies included with Meade LX200 models.
- **Massive LX200-type Fork Mounts:** Manufactured of the same aluminum castings as Meade LX200 models. Massive, rigid mounts that include the Meade LX worm-gear drive system with low periodic error for advanced photographic or CCD imaging applications.

SPECIFICATIONS: 7", 8", and 10" LX50's — Each complete telescope includes 8" or 10" f/10 Schmidt-Cassegrain or 7" f/15 Maksutov-Cassegrain optical tube assembly with EMC super multi-coatings; heavy-duty LX200-type fork mount; 5.75" LX worm gear system in R.A.; multi-function control panel; DC servo Declination motor; manual and electric slow-motion controls on both axes; setting circles on both axes; keypad hand controller; 4-speed drive controls on both axes; battery compartment accepting six (user-supplied) AA-size batteries; 25 ft. power cord for telescope operation from 12v. auto cigarette lighter plug; 6 x 30mm (7" and 8" models) or 8 x 50mm (10") viewfinder; 1.25" diagonal prism; Series 4000 Super Plössl 26mm multi-coated eyepiece (1.25"); standard equatorial wedge with elevation scale, bubble level, and azimuth control; complete operating instructions.

8" LX50 Schmidt-Cassegrain	**$1395.**
10" LX50 Schmidt-Cassegrain	**1695.**
7" LX50 Maksutov-Cassegrain	**1795.**
Variable-Height Field Tripod	**295.**

Packing and shipping in the 48 states: 8"—$105; 10"—$145; 7"—$125; 7" Tube Assembly—$65.

Meade Magellan™ II Computer-Corrector for LX50 Telescopes: Plug the Magellan II into the control panel of your LX50 and enjoy an incredible range of advanced capabilities. ■ Fast manual slewing to any object, either from input RA and Dec or from the 12,218-object database. ■ High-resolution 4096-pulse encoders (5.3 arc-minute precision), concealed in special LX50 encoder compartments. ■ Large 32-character, red-backlighted display. ■ Quick 2-star alignment. ■ Four-speed (2x, 8x, 16x, 32x sidereal) dual-axis drive corrector/microslewing system.

#2024: Magellan II for LX50's—Includes Magellan II hand controller *(shown above)*; encoders for both axes; all required mounting hardware. Installs to any LX50 in minutes. **$495.** + $15 packing and shipping in the 48 states.

MEADE LX50
Meade
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Meade 8" LX50 Schmidt-Cassegrain Telescope *(shown with optional Field Tripod)*

MEADE LX200

Meade
MEADE LX200 EMC
MEADE LX200
Meade
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GO TO
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Meade 10" LX200 Schmidt-Cassegrain Telescope

Prices shown are suggested U.S. national mail-order retail prices.

The largest-selling serious telescopes in the world.

In virtually every country in the world where serious telescopes are sold, more Meade LX200's are sold than all competing models *combined*. *Standard-equipment includes:*

- **Superb Optics:** LX200 diffraction-limited imaging capabilities are a legend in the industry; optical performance approaches that of a fine *ED* apochromatic lens.
- **Automatic GO TO Capability:** Meade LX200's are *the only commercial telescopes ever manufactured* that automatically GO TO any input R.A. and Dec., or to any of 64,359 objects in the onboard database, *to a precision of one arc-minute or better.*
- **LX200 High-Precision Pointing**™ is so precise it permits the positioning of *every* selected object on *every* commercially-available CCD chip *every* time, automatically — *a feat no other telescope priced under $40,000 can accomplish.*
- **Permanently-Programmable Smart Drive**™ routinely achieves 5 arc. sec. periodic error, an observatory standard.
- **9-Speed Dual-Axis Electronics:** Electronics that cover every possible contingency of telescope positioning—from 2x photo-guide, to 32x image centering, to 8°/sec. slewing across the sky, as well as 6 other dual-axis drive speeds in between.
- **Field Operation:** No other telescopes of such incredible capabilities transport so readily for field operation. The compact, optional #1812 Electronic DC Adapter allows for field powering directly from an automobile cigarette lighter plug.

SPECIFICATIONS: 7", 8", 10", and 12" LX200's — Each complete telescope includes 8" or 10" (f/6.3 or f/10) or 12" f/10 Schmidt-Cassegrain or 7" f/15 Maksutov-Cassegrain optical tube assembly with EMC super multi-coatings; heavy-duty fork mount with 4" polar ball bearing, dual-axis 5.75" worm gears, and multi-function control panel; manual and electric slow-motion controls on both axes; keypad hand controller with digital readout display, permanently programmable Smart Drive, 9-speed drive controls on both axes (7-speed on 12"), High-Precision Pointing, and GO TO controller; 64,359-object onboard celestial software library; 25 ft. power cord and adapter for telescope operation from 115v.AC; 8 x 50mm viewfinder; 1.25" diagonal prism (7", 8", 10") or 2" diagonal mirror with 1.25" adapter (12"); Series 4000 Super Plössl 26mm eyepiece; standard field tripod (7", 8", 10") or giant field tripod (12"); operating instructions.

8" LX200 Schmidt-Cassegrain	**$2795.**
10" LX200 Schmidt-Cassegrain	**3195.**
12" LX200 Schmidt-Cassegrain	**4495.**
7" LX200 Maksutov-Cassegrain	**3295.**

Packing and shipping in the 48 states: 8"—$105; 10"—$145; 12"—$215; 7"—$125.

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STARFINDER™

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Meade® Starfinder 10" Dobsonian ...*now only* *$449!*

Complete with 1.25" rack-and-pinion focuser, 5 x 24mm viewfinder, Super Plössl 26mm eyepiece, and premium-grade Pyrex® optical system.

Shown with optional #2010 Magellan I Computer System.

The lowest prices *ever* for Meade Starfinder Dobsonians — complete with these standard features:

Series 4000 SP26mm Eyepiece (1.25"): This $80 eyepiece permits all Meade Starfinder Dobsonians to perform absolutely to their maximum capabilities.

Professional-Grade Optical System with hand-figured optics of Grade-A fine-annealed Pyrex glass, *unlike the plate glass optics of other Dobsonians that can become thermally unstable.* Optics are multi-coated and meet the theoretical limits of resolution.

Rigid, Durable, Beautiful Dobsonian Mountings: Zero-backlash Teflon/Nylon bearings facilitate the quick location and easy tracking of celestial objects with extremely smooth motions of the telescope in both altitude and azimuth.

Full-Size 1.25" Rack-and-Pinion Focuser: For smooth, precise focusing of the image without wobble or backlash. Focus travel is 2.6"; accepts 1.25" eyepieces.

4-Vane Steel Secondary Mirror System: Permits locked-in support and precise centration and alignment of the secondary mirror.

5 x 24mm Viewfinder: Included with all Starfinder Dobsonian models for quick object-location in the main telescope. With crosshair eyepiece and 2-ring bracket.

Optical Tubes: Strong, spiral-wound Sonotubes™ with excellent insulating characteristics that reduce internal thermal currents to an absolute minimum.

Performance! Every Starfinder model opens up the skies to an extremely wide range *of serious visual observing:* all 110 Messier objects, thousands of NGC objects — nebulae, galaxies, star clusters, in all their variations of form, color, and extent, as well as the Moon and planets *in stunning high-resolution detail.* Starfinder Dobsonians are for visual observing; motor-driven Starfinder Equatorials may also be used for lunar and planetary photography, and even for limited deep-space photography.

Meade Starfinder Dobsonian Telescopes

Complete per specifications above:

6" f/8	**$249**
8" f/6	**349**
10" f/4.5	**449**
12.5" f/4.8	**795**
16" f/4.5	**1195**

Packing & UPS Shipping Charges to any address in the 48 states: 6"—$39; 8"—$49; 10"—$69; 12.5"—$79; 16"—$45 packing, shipped truck freight collect.

Dobsonian Deluxe Accessory Package...only $49.95!

Outfit your Meade Dobsonian with all of the most popular accessories for advanced observing. At the time you order any Dobsonian model, specify the following Deluxe Accessory Package for your telescope, in place of the standard-equipment focuser, viewfinder, and eyepiece, ***for a total of only $49.95 additional:***

Meade #77 2" Giant Rack-and-Pinion Focuser, with eyepiece-holders for both 2" and 1.25" eyepieces; includes drawtube lock and 2.6" focuser travel. *(reg. $59.95)*

Meade #637 6 x 30mm Achromatic Viewfinder, with wide 7° field; 2-ring metal bracket. *(reg. $49.95)*

Meade Series 4000 Super Plössl 9.7mm and 26mm multi-coated eyepieces — premium-grade eyepieces for high-resolution lunar, planetary, and deep-space observing. *(reg. $79.95 each)*

Purchased separately, the Deluxe Accessory Package sells for $269.80!

Meade Magellan I Telescope Computer System

Attach the optional Magellan I Telescope Computer System to your Starfinder Dobsonian and finding any of 12,218 celestial objects, or *any* object of known R.A. and Dec., is almost as easy as pointing the telescope! Magellan I's database includes:

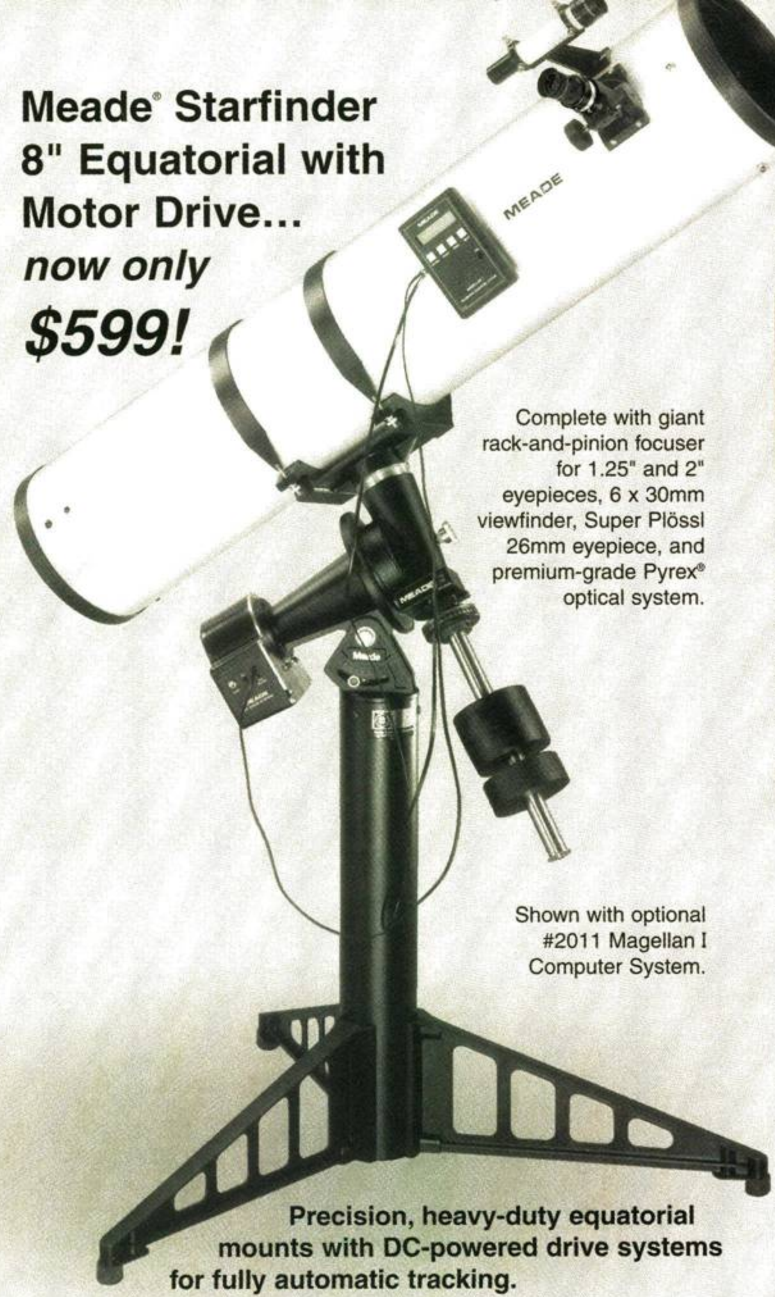
7,840	NGC objects; the complete NGC catalog
4,093	IC objects from the Index Catalog
125	user-defined objects
110	Messier objects; the complete catalog
42	alignment stars for the Magellan system
8	major planets, from Mercury to Pluto
12,218	objects, total

MEADE
ENTER MODE PREV NEXT
ON
MAGELLAN I
TELESCOPE COMPUTER SYSTEM

Magellan I is supplied *complete* with control/display unit (4" x 5" x 1.25"); premium-grade, high-resolution encoders for each telescope axis (encoder precision is 5.3 arc minutes); RS-232 serial interface; bracket for placement of the controller on the telescope tube; and attachment hardware. Just add the user-supplied 9v. transistor radio battery, and Magellan I is ready to use. First-time installation is quick and simple. **#2010: for Meade Starfinder Dobsonian 6", 8", 10", 12.5", or 16" — $295.** Packing & shipping in the 48 states—$15.

Note: Many manufacturers compromise telescope performance by using low-cost plate glass — glass which can become thermally unstable — in their primary and secondary mirrors, or else they charge a premium for Pyrex optics. *Meade Starfinder Dobsonian and Equatorial telescopes include Pyrex glass, exclusively, at no additional cost.*

Meade® Starfinder 8" Equatorial with Motor Drive... *now only* ***$599!***



Complete with giant rack-and-pinion focuser for 1.25" and 2" eyepieces, 6 x 30mm viewfinder, Super Plössl 26mm eyepiece, and premium-grade Pyrex® optical system.

Shown with optional #2011 Magellan I Computer System.

Precision, heavy-duty equatorial mounts with DC-powered drive systems for fully automatic tracking.

Professional-Grade Optical System: Hand-figured, parabolic primary mirror and elliptical flat secondary, both of Grade-A Pyrex glass. Optics are multi-coated and meet the theoretical limits of resolution.

Accessories and Components: Premium-grade multi-coated SP26mm eyepiece (1.25"); 6 x 30mm viewfinder with wide 7° field; strong, durable, spiral-wound optical tube with attractive white finish.

Precision Equatorial Mount: Manufactured of machined aluminum to tolerances of .001" or better, with 4"-dia. pier and die-cast tripod legs for rock-solid support of the optical tube. Moves effortlessly from object to object on precision bearing surfaces. Polar and Dec. shafts are 1" solid steel. Setting circles on both axes.

Meade Starfinder Equatorial Telescopes

6" f/8	$499	10" f/4.5	699
8" f/6	599	16" f/4.5	2695

Packing & UPS Shipping Charges to any address in the 48 states: 6"—$65; 8"—$75; 10"—$90; 16"—$55 packing, shipped truck freight collect.

To Order any Starfinder model: contact your authorized Meade Advanced Products Dealer, below. Prices shown are suggested U.S.A. mail-order retail prices.

ASTRONOMICS, Norman, OK.
Orders: 800-422-7876; Info.: 405-364-0858.

FOCUS CAMERA, Brooklyn, NY.
Orders: 800-221-0828; Info.: 718-436-6262.

LUMICON, Livermore, CA.
Orders: 800-767-9576; Info.: 925-447-9570.

OCEANSIDE PHOTO & TELESCOPE, Oceanside, CA.
Orders & Information: 800-483-6287.

POCONO MOUNTAIN OPTICS, Moscow, PA.
Orders: 800-569-4323; Info.: 570-842-1500.

RIVERS CAMERA, Dover, NH.
Orders: 800-245-7963; Info.: 603-742-4888.

SHUTAN CAMERA & VIDEO, Chicago, IL.
Orders/Info: 800-621-2248; IL: 312-332-2000.

Canada:

EFSTONSCIENCE, Toronto, Ontario.
Orders & Information: 416-787-4581.

KHAN SCOPE CENTRE, Toronto, Ontario.
Orders & Information: 416-783-4140.

Battery-Powered Cordless Drive System: For fully automatic tracking of celestial objects. Operates over 50 hours from 6 (user-supplied) AA-batteries or from 12v. auto cigarette lighter plug, using optional 25 ft. cord.

2" Giant Focuser: Meade #77 giant rack-and-pinion focuser is included as standard equipment, with eyepiece-holders for both 1.25" and 2" eyepieces.

Starfinder Equatorial 16: Includes equatorial mounting with 1.5" steel shafts, Sealmaster ball bearings, 6" dia. pier, and 6 x AA-size battery-powered worm gear drive; 8 x 50mm viewfinder; #77 giant focuser.

Magellan I Telescope Computer System: Use the Magellan I computer to manually slew the telescope quickly to any of 12,218 database objects, or to any object of known R.A. and Dec. Specifications and object database are identical to Magellan I for Starfinder Dobsonians *(see facing page).*

#2011: for Meade Starfinder Equatorial 6", 8", or 10" . . . . . $295.
#2012: for Meade Starfinder Equatorial 16". . . . . 295.

Magellan II Computer-Corrector: Plug the Magellan II into the control panel of your Meade Starfinder Equatorial and you have all the capabilities of the Magellan I, above, including 12,218-object database, *plus* a 4-speed (2x, 8x, 16x, 32x), dual-axis, drive corrector/microslewing system.

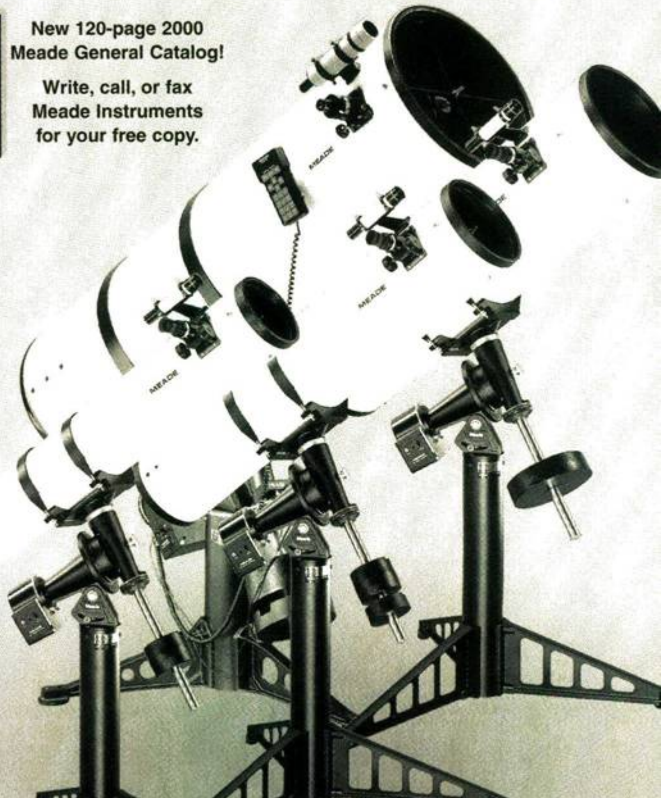
#2018: for Starfinder Equatorial 6", 8", 10" . . . . 495.
#2019: for Starfinder Equatorial 16" . . . . 595.

Packing & shipping in the 48 states: Magellan I – $15, Magellan II – $20.

Special Eyepiece Offer! At the time you order any Meade Starfinder Equatorial telescope, you can buy a Meade Series 4000 Super Plössl 9.7mm eyepiece ***for only $29.95!*** *Purchased separately, the SP9.7mm eyepiece sells for $79.95.*

New 120-page 2000 Meade General Catalog!

Write, call, or fax Meade Instruments for your free copy.



ADVANCED PRODUCTS DIVISION
Meade Instruments Corporation
The largest-selling telescopes in the world. □ *A NASDAQ company.*
6001 Oak Canyon, Irvine, California 92618 □ (949) 451-1450
FAX: (949) 451-1460 □ *www.meade.com*

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MEADE RESEARCH-GRADE ACCESSORIES

Series 4000™ Super Plössls
52° field; multi-coated

Meade 4-element Super Plössls, updated and redesigned to utilize the latest in optical glass-types, are the finest general-purpose eyepieces available. For observing hairline lunar and planetary detail, splitting close doubles, or for deep-space; guaranteed to deliver more contrast and image sharpness than any other brand. Rubber eyeguards fold down for eyeglass wearers–a feature not available on competing brands. Multi-coated. All focal lengths through 32mm are parfocal.

Super Plössls (SP; 4-elements; 1.25"; 52°):
6.4, 9.7, 12.4, 15, 20, 26mm each: **$79.95** (4.54)
32mm (52°); **40mm** (44°) each: **99.95** (5.26)
56mm (52°; 2") **199.95** (7.02)

Series 4000™ Ultra Wide Angle
84° field; multi-coated

The ultimate eyepieces; extreme image sharpness over an amazing 84° field. A perfect optical match with Schmidt-Cassegrains and fast Newtonians.

Ultra Wide Angle (UWA; 8-elements; 1.25"; 84°)– **4.7mm: $169.95** (5.26); **6.7mm: 199.95** (5.26); **8.8mm** (1.25"/2"): **239.95** (7.02); **14mm** (1.25"/2"): **299.95** (7.02)

Series 4000™ f/6.3 Focal Reducer/ Field Flattener

Manufactured to exclusive Meade optical designs; threads on to any Meade or Celestron Schmidt-Cassegrain rear cell and converts f/10 scopes to f/6.3 (or f/6.3 SCT's to f/4), while significantly flattening the field. Use with SCT visual or photo accessories. Actual visual field is increased by 56%, for fine wide-field views of star fields and nebulae. In astrophotography, reduces exposure times by about 50%, while producing an actual field diameter of 1.5° at the film plane. A tremendous aid with CCD imagers in reducing image size for locating and centering images on CCD chips. 4-element optics; multi-coated; 41mm clear aperture. **$129.95** (5.26)

2x Telenegative Barlow (1.25")

#122: Doubles eyepiece power with sharp, high-resolution, high-contrast imaging on telescopes of all types. 27mm dia. (26mm clear aperture). Excellent corrections for chromatic and spherical aberrations at all photo-visual wavelengths. Multi-coated. 1.25" **$47.95** (4.54)

2x Short-Focus Barlow (1.25")

#126: Only 2.5" long, the #126 works well with any telescope accepting 1.25" eyepieces, even those with limited focus range. Maintains the high image quality of the #122, above. Insert the #126 into star diagonal for 2x or insert star diagonal into #126 for 3x. 26mm clear aperture. Multi-coated. **$47.95** (4.54)

2x-3x Variable Barlow (1.25")

#127: Precision internal sliding lens assembly permits continuously variable power settings between 2x and 3x. Engraved scale indicates power in use. Yields bright, sharp, high-contrast images on telescopes of all types. Multi-coated; 1.25". **$59.95** (4.54)

2" Diagonal Mirror

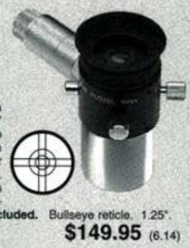
#929: Permits use of wide-field 2" oculars. Threads on to rear cell of Meade and Celestron SCT's. Includes multi-coated precision optical flat made at the Meade factory; with 1.25" eyepiece adapter. **#930:** Same as #929 but with 2" barrel to fit into focusers with 2" eyepiece-holders.

#929 or **#930,** each: **$99.95** (6.85)

45° Erecting Prisms

Fully coated roof prisms to invert the astronomical image in Schmidt-Cassegrains or refractors during terrestrial observations, while presenting a convenient 45° observing angle. Specify **#927** (.965"), **#928** (1.25"), or **#931** (fits .965" focuser, accepts 1.25" eyepieces). **$42.95** (3.86)

World's Most Advanced Illuminated Reticle Eyepiece



Series 4000 Plössl 9mm, with rubber eyecup and micrometric X-Y positioning of the reticle within the field. Greatly facilitates locking on the guide star. Sharp high-power imaging, excellent eye relief. Wireless red LED illuminator with adjustable brightness control. Multi-coated optics. **Internal batteries included.** Bullseye reticle. 1.25". **$149.95** (6.14)

Series 4000 Plössl 9mm—Same as above but with 6 ft. cord and plug for Meade LX3, LX5, LX6, LX100, LX200, and APO power panels, in place of wireless illuminator. **$129.95** (5.26)

Series 4000 Photo-Visual Color Filters (1.25")–Premium filters, made of purest crown optical glass, dyed in the mass. For increased contrast and resolution on the Moon and planets. Thread into the barrels of virtually all 1.25" eyepieces sold today. Fully coated.

#8 Lt. Yellow; #11 Yellow Green; #12 Yellow; #21 Orange; #23A Lt. Red; #25A Red; #38A Dark Blue; #47 Violet; #56 Lt. Green; #58 Green; #80A Blue; #82A Lt. Blue each **$14.95** (2.73)

Set #1–4 filters: #12, #23A, #58, #80A **49.95** (4.54)
Set #2–4 filters: #11, #25A, #47, #82A **49.95** (4.54)
Set #3–4 filters: #8, #21, #38A, #56 **49.95** (4.54)

Series 4000 Moon Filter (#ND96): Reduces glare and irradiation during lunar observing. 13% uniform light transmission across the visual spectrum. Threads into 1.25" barrels. **$16.95** (2.73)

#905 Variable Polarizer (1.25")

For glare reduction in observing the Moon. Includes two Polarizer filters mounted in a machined cell and permits continuously variable light transmission from 5% to 25%, to compensate for varying lunar surface brightness according to the Moon's phase and the aperture of the telescope. Accepts 1.25" eyepieces. **$49.95** (5.26)

Electric Focusers for SCT's

For extremely smooth microfocusing of the image. Does not affect use of the manual coarse-focus knob.

#1206 Electric Focuser: Plugs into control panel of Meade 8", 10", 12" LX200 models and operates from LX200 hand controller. **$149.95** (7.48)

#1205 Electric Focuser: For **all** other Meade 8", 10", 12" SCT models; includes separate hand controller; accepts one self-contained (user-supplied) 9v. battery. **$169.95** (7.88)

#777 Off-Axis Guider for SCT's

Internal prism diverts light for monitoring telescopic image during long-exposure astrophotography. Threads to any Meade or Celestron rear cell. Use with illuminated reticle eyepiece and T-Mount for your 35mm camera. **$79.95** (6.85)

Series 4000™ 2x Apochromatic Barlow Lens

#140: The most advanced Barlow lens available for commercial telescopes, the Meade #140 includes 3-element, multi-coated, air-spaced optics. Doubles the power of any eyepiece with which it is used and yields images absolutely unmatched in resolution, contrast and color correction. The #140 optically complements any telescope — refractor, reflector, or Schmidt-Cassegrain. Accepts 1.25" eyepieces. Mechanical components are of machined aluminum and brass. Lens diameter is 28mm; clear aperture 26mm. **$79.95** (5.26)

Series 4000™ Super Wide Angle
67° field; multi-coated

For exquisite wide-angle images at low-to-medium powers, with pinpoint edge-of-field resolution. Ideal for star fields, galaxies, and other deep-space phenomena. SWA 13.8mm, 18mm, and 24.5mm are superb complements to the #140 Barlow, above.

Super Wide Angle (SWA; 6-elements; 1.25"; 67°)–**13.8mm: $139.95** (4.54); **18mm: 149.95** (4.54); **24.5mm: 179.95** (5.26); **32mm** (2"): **239.95** (7.02); **40mm** (2"): **299.95** (7.02)

Series 3000™ Plössls
50° field; multi-coated

Meade Series 3000 Plössls yield the finest image corrections obtainable from the classical 4-element Plössl design. Focal lengths from 5mm through 25mm are parfocal, so that, at most, only slight refocusing of the image is necessary from eyepiece to eyepiece. Unlike competing moderately-priced Plössls, Meade Series 3000's are **multi-coated** for maximum light transmission and image contrast. Chrome-plated brass barrels are threaded for standard filters. All eyepieces are fitted with fold-down rubber eyecups for comfortable observing. The PL40mm *(far right in photo),* an excellent complement to any ocular set, produces spectacular low-power, wide fields, ideal for scanning the Milky Way. Manufactured exclusively to Meade optical designs, Series 3000 Plössls yield fine, high-resolution results on reflectors, refractors, and Schmidt-Cassegrains of any focal ratio.

Series 3000 Plössls (4-elements; 1.25"; 50°)
5, 6.7, 9.5, 16, 25mm each: **$49.95** (3.86); **40mm** (44° field): **$79.95** (3.86)

#911B
#910B
#908B
#911N
#910N
#908N

Series 4000 Nebular Filters—Premium multi-layer interference filters, the finest obtainable. Use broadband ("B") filters to block most forms of light pollution; use narrowband ("N") filters in heavily light-polluted areas or for extremely high-contrast observing of faint nebulae.

#908B–Threads into 1.25" eyepieces, 26mm dia. **79.95** (4.54)
#910B–Threads into 2" eyepieces, 44mm dia. **119.95** (5.26)
#911B–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia. **99.95** (5.26)
#908N–Threads into 1.25" eyepieces, 26mm dia. **89.95** (4.54)
#910N–Threads into 2" eyepieces, 44mm dia. **129.95** (5.26)
#911N–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia. **119.95** (5.26)

#911X
#910X
#908X

Series 4000 Oxygen-III Filters Observe diffuse emission and planetary nebulae as you never thought possible! Exclusive Meade *60-layer* interference coating technology isolates the 496nm and 501nm O-III lines to tremendously enhance observable nebular structural detail in all telescopes.

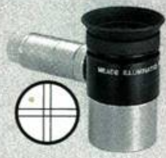
#908X–Threads into 1.25" eyepieces, 26mm dia. **99.95** (4.54)
#910X–Threads into 2" eyepieces, 44mm dia. **159.95** (5.26)
#911X–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia. **149.95** (5.26)

Modified Achromatic Eyepieces

Meade 3-element MA eyepieces yield sharp, well-corrected images on the Moon, planets, and deep-space at a reasonable price. Multi-coated; threaded for filters; 1.25" barrel diameter. Apparent field: 40°. **MA 9, 12, 25, 40mm.**

each: **$37.95** (4.54)

MA12mm Illuminated Reticle Eyepiece



Excellent 3-element optical system, long eye relief, fully coated, with double crossline reticle; rubber eyecup. Wireless red LED illuminator and variable brightness control. 1.25". **Batteries included.** **$99.95** (3.45)

As above but with 6 ft. cord and plug for Meade telescopes with power panels, in place of wireless illuminator. **$79.95** (5.26)

Camera Adapters

Professional-quality adapters for rigid coupling of telescope-to-camera. Use for either Eyepiece-Projection or Prime Focus. Precision-machined of aluminum and brass, threaded for filters. Use with T-mount, available separately.

.965": **$27.95**; 1.25": **$29.95** (3.86)

Variable-Projection Camera Adapter (1.25")

Machined sliding cell allows variable projection power in eyepiece-projection photography; permits precise selection of correct photo power in lunar and planetary photography; threaded for filters. Use with T-mount for your camera.

$39.95 (3.86)

Variable Tele-Extender

For eyepiece-projection photography with any Meade or Celestron SCT. Threads on to eyepiece-holder. Sliding cell with lock permits wide range of projection magnifications with the same eyepiece. Use with T-mount for your camera. **$39.95** (3.86)

T-Adapters for SCT's

Rigidly couples camera to telescope for prime focus photography with any Meade or Celestron Schmidt-Cassegrain. Use with T-Mount for your 35mm camera.

$26.95 (3.86)

CCD-Photo-Visual Flip-Mirror Systems

An essential accessory for imaging with ***any*** brand of CCD imager or for astrophotography with a 35mm camera. Flip mirror "down" to center the image while viewing with an eyepiece at 90°; flip mirror "up" to pass light on to CCD chip or 35mm camera film plane. Each unit includes: precision optical-flat Pyrex® mirror; 2-axis mirror-adjustment screws and locks for precise image centering; extra-fine helicoid focusing of the eyepiece; extension tubes for attaching either 35mm camera (using T-Mount) or CCD imager (using either T-threads or 1.25" barrel). Threads to rear cells of all Schmidt-Cassegrain telescopes; may remain on telescope and used in place of diagonal prism for visual observing as well.

"Over the past 10 years I have used all manner of flip-mirrors. The Meade Flip-Mirror Systems are absolutely the best—rock solid, high-precision, beautifully manufactured; they virtually eliminate all flexture between the CCD and telescope." — Jack Newton

NEW!
MEADE
FLIP-MIRROR SYSTEM
MEADE

#644 Flip-Mirror System: Accepts any 1.25" eyepiece. Mirror clear aperture: 22mm. Use with CCD's up to Pictor 416XT or ST-7, or smaller; or visual observing with 1.25" eyepieces. **$149.95** (7.02)

#647 Flip-Mirror System: Accepts either 1.25" or 2" eyepieces. Mirror clear aperture: 40mm. Recommended for full-field 35mm astrophotography or with CCD's of any size, including all Meade Pictor Series through 1616XT, as well as ST-4 through ST-8; or for visual applications with 1.25" or 2" eyepieces. **249.95** (8.49)

#157 1.25" Adapter: Permits use of either Flip-Mirror on telescopes with 1.25" eyepiece-holders. (Requires approx. 2" additional focus travel with #644, 3" with #647.) **15.00** (3.86)

#644

#647
MEADE
FLIP-MIRROR SYSTEM

Epoch 2000® Sky Software

The most powerful astronomical software ever made available can now be yours for only $149!

Epoch 2000sk *(upper display at left):* Now you can use the most advanced, most precise full-color sky software ever created, to zoom-in on telescopic fields **smaller than one arc second!** With star positions displayed as precisely as **0.01 arc second,** the Trapezium in Orion is no longer shown as a single point, as in other software, **but as four precisely oriented starpoints, just as they appear in the telescope.** No longer do you need to guess the R.A. and Dec. of an object located away from the field center, as in other programs: Epoch 2000sk dynamically reads out the R.A. and Dec. of the cursor position anywhere in the field **and updates R.A. and Dec. instantaneously as the cursor is moved about the field.** Meade LX200 owners can use Epoch 2000sk for remote auto-centering of objects in the telescopic field **to a precision of 30 arc seconds,** routinely!

Print professional-quality star charts in either black-and-white or color, at any zoom setting or sky scale between 180° and one arc second, with your own customized borders, headers, footers, margins, fonts, colors, and grids.

Epoch 2000ip Image Processing Software *(lower display at left)*: Epoch 2000ip makes it easy to enhance and analyze your CCD images with the same sophisticated techniques used by professional astronomers to uncover hidden structure in a spiral galaxy or obscure detail on the surface of a planet. This powerful software includes virtually every technique available for image enhancement. Techniques that bring out detail totally invisible in your original image, transforming it from the ordinary to the spectacular.

EPOCH 2000sk Sky Software: 281,000 objects supplied on 3.5" discs for Windows 3.1 or higher; fully compatible with Windows 95 . . . . . . **$149**

EPOCH 2000sk-CD Sky Software: 19 million objects, including the complete Hubble Guide Star Catalog; supplied on CD-ROM **179**

LX200 Interface Cable: for Meade LX200 operation by Epoch 2000sk **25**

EPOCH 2000ip Image Processing Software: Supplied on 3.5" discs for Windows 3.1 or higher; fully compatible with Windows 95 . . . . . . **$199**

Series 4000™ f/3.3 CCD Focal Reducer/Field Flattener

f/3.3 CCD FOCAL REDUCER

NEW!

Revolutionary 3-element Meade design permits ultrafast CCD imaging with **increased** edge-of-field resolution and color correction! Reduces CCD exposure times by up to 80%. Threads on to the rear cell of any Meade or Celestron Schmidt-Cassegrain. Converts f/10 Schmidt-Cassegrain telescopes to **f/3.3** and f/6.3 SCT's to **f/2.** Variable T-Adapter (included) allows range of f/ratios between f/3 and f/5 on f/10 SCT's and between f/1.9 and f/3.2 on f/6.3 SCT's. Use with CCD imagers of any brand and chip dimensions. Not for visual or photographic applications. Multi-coated; 41mm clear aperture. **$149.95** (5.26)

Plössl 25mm Illuminated Reticle CCD Framing Ocular

NEW!
MEADE
PLÖSSL
CCD FRAMING

Displays rectangular frames of all popular CCD chip sizes, including all Meade Pictor models and ST-4 through ST-8. Shows precisely the image size and orientation that appear on CCD chip. Insert directly into telescope eyepiece-holder, or use with Flip-Mirror *(above).* Includes 4-element coated Plössl optics; lockable spacer ring to fix focus position; rubber eyecup; variable LED illumination control; batteries. 1.25". **$129.95** (4.54)

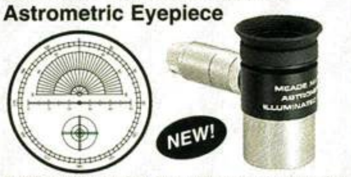
#825 8 x 25mm Right-Angle Viewfinder for ETX-90

Permits comfortable right-angle viewing. Replaces standard-equipment finder on 90mm ETX models, using the same bracket. Wide-angle, achromatic, coated optics; actual field 7.5°. Precise helicoid focusing. **$49.95** (4.26)

#64 T-Adapter for ETX®

Threads to the photo port of all ETX-90 and ETX-125 models. Rigidly couples any 35mm camera with removable lens to the telescope for lunar, planetary, or terrestrial photography. Includes extension tube for longer effective focal length, if desired. Use with T-Mount for your 35mm camera. **$34.95** (3.86)

MA12mm Illuminated Reticle Astrometric Eyepiece



A high-precision eyepiece for a wide range of astronomical measurements. Includes four red-illuminated, laser-etched scales for measuring double star angular separations, position angles, planetary diameters, and lunar crater diameters, and for long-exposure photo-guiding. Modified Achromatic 3-element coated optics; diopter adjustment; rubber eyecup; variable LED illumination control; batteries. 1.25". **$119.95** (4.26)

Series 4000™ 8mm – 24mm Zoom Eyepiece

NEW!

The finest zoom eyepiece available. High-resolution 7-element multi-coated optics, with 55° field at 8mm. Graduated scale in 1mm units indicates exact focal length in use. High-eyepoint yields comfortable observing even with eyeglasses. Internal zoom lenses move on the smoothest, most precisely-machined tracks yet developed for zoom optics. Performance is fully consistent with the finest fixed-focal length eyepieces. Threaded for filters; rubber eyecup; 1.25". **$219.95** (6.38)

ETX® Hard Carrying Cases

For secure storage or travel with your ETX. Thick-wall construction and die-cut foam lining. Accepts telescope, plus optional eyepieces, erecting prism, table tripod, hand controller, *etc.* Includes two steel latches with key.

#774 Case for ETX-90 models: **99.95** (8.58)

#775 for ETX-125EC: **149.95** (13.38)

#932 45° Erecting Prism for ETX®

For terrestrial observing with any ETX-90 or ETX-125 model. Yields correctly oriented image and convenient 45° observing angle. Threads to ETX rear cell. Accepts any 1.25" eyepieces. Coated roof prism optics. **$49.95** (3.86)

Advanced Field Tripod for ETX-125

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Venus by Day

Allow me to offer another way to find Venus in the daytime than by offsetting from the sun (*Astronomy*, December 1999). Offset using a Dobsonian mount instead of an equatorial mount.

Using Venus's right ascension and declination as found each month in this magazine or in an ephemeris, pinpoint its position on your trusty planisphere. Dial that point to the meridian and note the time of day for that date (taking into account your local time correction). When Venus is on the meridian, its altitude above your horizon equals 90° less your latitude, plus or minus Venus's declination.

Prefocus your scope because an even slightly out-of-focus scope will not show Venus by day. Once your technique is perfected on the "Planet of Love," try for some 1st-magnitude stars. It's dazzling to see them in the daytime against a blue sky. — *Herman M. Heyn, Baltimore, Maryland*

Brown Dwarfs Predicted Earlier

In "A Century of Astronomy" from *Explore the Universe 2000*, author William Sheehan lists 1995 as the year when the first brown dwarfs were discovered. I would like to point out that the existence of brown dwarfs was theorized in a paper I published in 1963 in the *Astrophysical Journal* (#137, 1121); a companion paper presented the first calculations on the structure and evolution of these objects. These papers predicted that the universe is likely to contain a large number of these objects, not only as luminous objects, but also as dark objects. If the first detection of these objects (in 1995) is an important event in the history of science, then the prediction for their possible existence (in 1963) should be given equal or greater importance.

Incidentally, before the introduction of the term "brown dwarf," these objects were referred to as "Kumar objects." — *Shiv S. Kumar, Dept. of Astronomy, University of Virginia, Charlottesville, Virginia*

Lunar Base Redux

I keep wondering about the seemingly big push for martian landers, probes, or manned flights, when the best option for expanding planetary exploration is still a well-stocked lunar base. Beginning with such a platform could lead toward martian exploration and would also give us a chance to review the effects on expensive equipment left on the lunar surface for 30-plus years. — *Edwin Lindley, Jr., Pico Rivera, California*

Sagan Not Alone

Carl Sagan was a great man as many will attest. This is so even in light of Kelly Whitt's observation that Sagan "clearly sacrificed his family in exchange for fame" (November 1999). Might I suggest, however, that there are many men far greater than Sagan who sacrificed fame for their family. — *Ed Jackson, Tampa, Florida*

Never Forget

I was pleased to see Carl Sagan given long overdue recognition in your magazine. At the time of his death, your magazine did not provide a feature article fitting a person of Sagan's popularity and reputation. Your coverage in the recent edition makes up somewhat, although it was promoting a book.

Notwithstanding this, I enjoy your magazine each month. — *Andy Gaul, Dundas, Ontario, Canada*

Calendars Phase Out Moon

Desk and personal appointment calendars are sold in an assortment of sizes, formats, colors, and textures. Not many of these calendars depict the moon's phases.

I wonder whether this signals a "waning" interest in easily observable sky events on the part of the public or if it is a matter of calendar companies doing cost-saving shortcuts. I prefer the lunar phase designations to help remind me of basic celestial events and to show me when adequate deep-sky observing is possible. Such shortsightedness does not pay homage to the historical development of time reckoning. Luckily, I have at my disposal fine monthly periodicals such as *Astronomy* to give me this information, but I don't usually carry a magazine with me. — *Randall Wehler, Willmar, Minnesota*

John Bucce

New Old Stuff

In his letter "Too Many Translations" (October 1999), Scott Zilmer complains about brief descriptions of measurement units. I wonder if he felt that way before he knew what a parsec was? I enjoy reading *Astronomy* because it is easy to understand, geared toward beginners like me. Someone who knows nothing about astronomy can read the articles and come away with a good understanding of what was written. And that's how it should be, I believe. — *James Parnell, Gordon, Pennsylvania*

Both Sides Now

I was impressed by "Cassini's Nuclear Risk" (August 1999). Like the author of the article, David Grinspoon, I too "believe strongly in both environmentalism and space exploration."

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This is the first article I've read in which both sides of the issue were treated seriously. — *Ellen Kaye-Cheveldayoff, Blaine Lake, Saskatchewan, Canada*

Loves His Saturn

It may be a small world, but the last time I checked, Earth was 7,917 miles in diameter, not 4,000 miles as Phil Harrington states in "Falling for Jupiter and Saturn" (October 1999). Harrington is correct about one thing, though: As was his, my first view of Saturn through a telescope was also an electrifying experience. Seeing that tiny orange object "live" was far more impressive to me than any photograph I had ever seen.

Now, every chance I get, I point my scope at Saturn and let strangers take a peek. Jupiter may be a good friend, but I've really fallen for Saturn. — *Thomas Sales, Soberest, New Jersey*

Say What?

I just read Bob Berman's article "The Art of Skyspeak" (September 1999), and I'm a little confused. What constellation is the star Faged-daboudit located in? And is it pronounced fah-GED-da-Boo-dit or fah-GED-da-Bhow-dit? — *Terrell Kent Holmes, Long Island City, New York*

Either way is correct, mostly because this constellation exists in the Dahnt-hva-cluu-darlinn Galaxy and pronunciation is the least of its problems. — Astronomy editors

To the Moon, Alice

Thanks so much for the pronunciation article a few issues back. For the five years I've been a subscriber, I thought Camelopardalis was two African animals and Ralph Cramden's wife. And Boötes something that young women today wear with dresses. — *Troy J. Kuchman, North Bergen, New Jersey*

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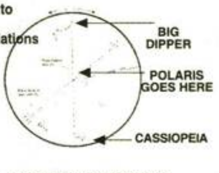

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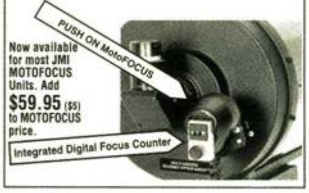

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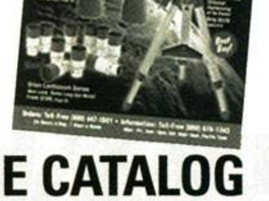

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TIMELY TRANSIT

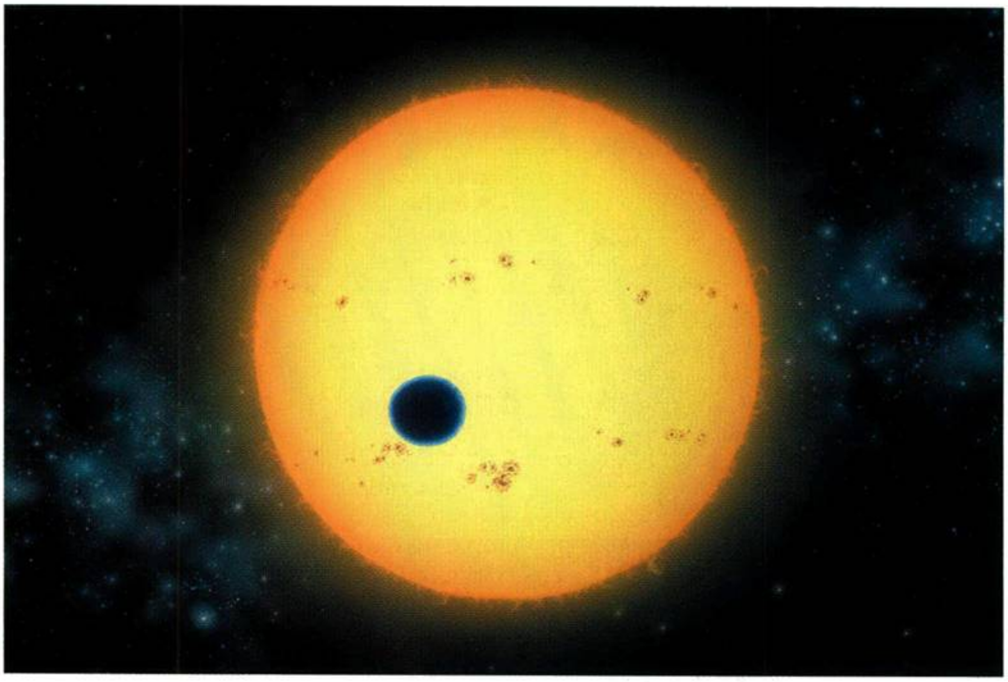
Planet Caught Crossing Face of Distant Star

▶ For the first time, astronomers have confirmed the dimming of a distant star as a planet crossed in front of it, an event called a transit. This transit of the sunlike star HD 209458, which is about 150 light-years away in Pegasus, allowed astronomers to gain unprecedented insight into the physical nature of the extrasolar planet. The planet appears to be a puffed-out gas giant orbiting extremely close to the star. The planet has an average density of just 38 percent that of water.

Two teams of astronomers independently discovered the planet by detecting its gravitational influence on the star. This indirect-detection method yields little information about the planet itself other than its minimum mass and orbital characteristics.

One team, led by David Latham of the Harvard-Smithsonian Center for Astrophysics and Michel Mayor of the Geneva Observatory, discovered the planet in June 1999. The other team, led by Geoff Marcy of the University of California at Berkeley and Paul Butler of the Carnegie Institution, discovered the planet on November 5.

Both groups' data showed that the planet has a minimum mass 63 percent that of Jupiter and that it orbits its star in a nearly circular path every 3.523 days at an average distance of about 0.045 astronomical unit (one AU is the average Earth-sun distance of about 93 million miles).



Lynette Cook

This painting shows what the planet's transit of HD 209458 might look like if astronomers could have a close-up view.

A transit can occur only if a planet's orbital plane is nearly edge-on to Earth's line of sight. But because the planet orbits so close to the star, both groups realized there was a 10 percent chance that the planet would transit the star.

Latham notified Dave Charbonneau of the Center for Astrophysics and Tim Brown of the National Center for Atmospheric Research, who detected two complete transits in September with the 4-inch STARE telescope in Colorado.

Marcy contacted Greg Henry of Tennessee State University. Using a 32-inch robotic telescope in southern Arizona, Henry detected a partial transit (the star set before the transit was complete) on November 7. "The transit occurred at exactly the time predicted by Marcy and Butler's observations," says Henry.

Both teams measured a drop of about 1.6 percent in the star's magnitude 7.6 brightness during the transit. Based on this decrease, Charbonneau and Brown calculated that the planet must be about one-eighth the diameter of its parent star. This would make the planet about 30 percent wider than Jupiter.

Because the planet's orbit is nearly edge-on, astronomers know that its minimum mass is almost identical to its actual mass. Dividing the planet's mass by its volume yields the low density of 38 percent that of liquid water. Saturn, the least dense planet in the solar system, has an average density of 69 percent that of water. "For the first time we get the true mass, the actual size, and we can calculate the mean density," says Henry. "So a lot of information comes from just this single observation."

At a distance of only 0.045 AU, the planet could be as hot as 3,000° F. Theoretical calculations by a group led by Adam Burrows of the University of Arizona in Tucson predicted that such hot Jupiters would be bloated. The heat of the star causes the planet's central regions to expand. "It's puffed out as we expected," says Burrows. "It's made mostly of hydrogen because nothing else could be that extended. It couldn't possibly be a giant terrestrial planet." — Robert Naeye

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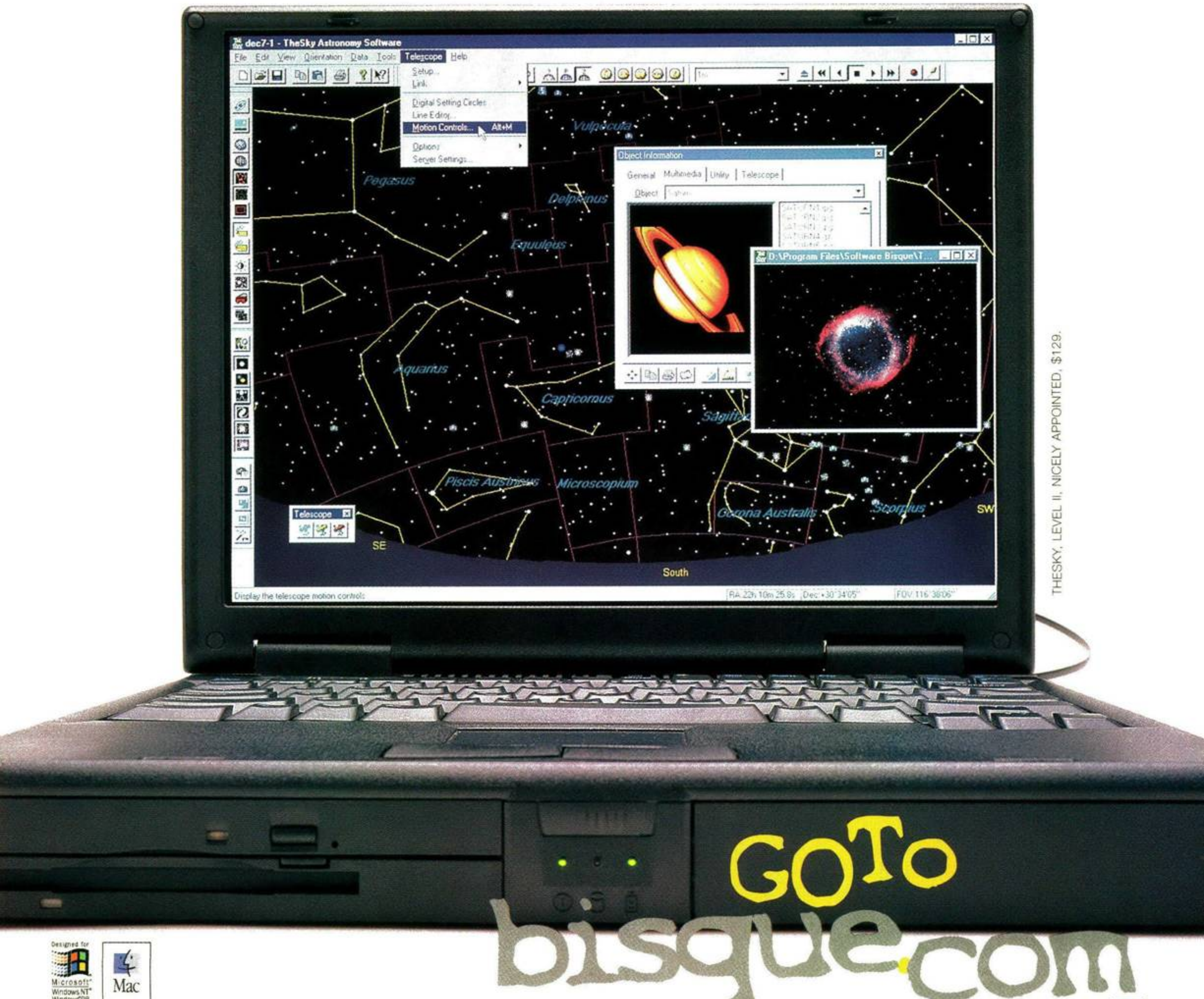

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INTERGALACTIC DEBRIS

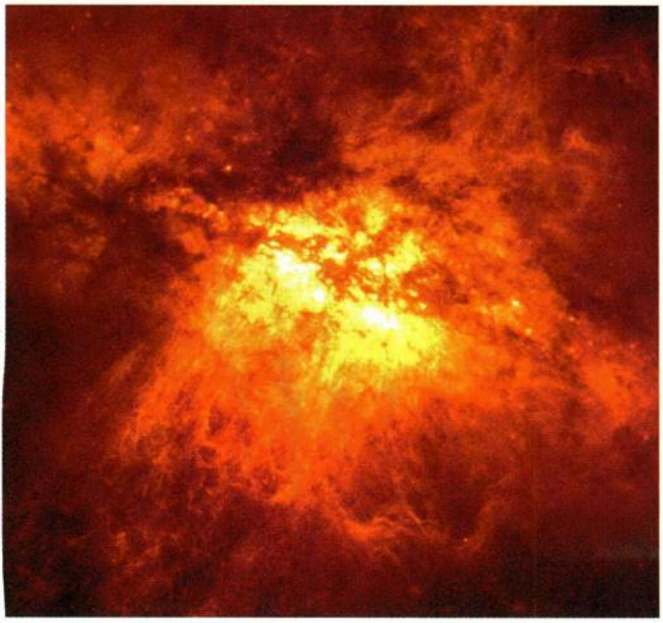
Starburst Galaxy Gases Can Become Superwinds

▶ Active starburst galaxies such as M82 in Ursa Major spew material farther into intergalactic space than predicted, via superwinds that escape the gravity of those galaxies. Matthew Lehnert, Timothy Heckman, and Kimberly Weaver report in *The Astrophysical Journal* that M82's superwinds carve ridges along areas of lower temperature gradients in starbursts. Along the way, superwinds collide with and carry material mixed in at the starburst origin. When superwinds meet gas clouds and heavy elements in the galactic halo, they sometimes reenergize and reheat enough to emit detectable x rays, which shoot beyond the host galaxy.

Astronomers measuring redshifted optical emission from M82 originally discounted x-ray data gathered simultaneously, says researcher Timothy Heckman of the Department of Physics and Astronomy at Johns Hopkins University. Improved satellite images prompted a reexamination of older data and led to new theories on the deposition of material from starbursts. Researchers now describe superwinds as vehicles responsible for transporting stellar by-products such as oxygen, silicon, and iron throughout the intergalactic medium (IGM).

"Gases excited by starbursts become superwinds, carrying x rays and elements and traveling along temperature ridges to intergalactic space," Heckman says. In a prolific star-forming galaxy as dynamic as the disk-shaped M82, superwinds punch out along its minor axis, creating enormous streams of "hot," supercharged particles. Superwinds cool rapidly — thus escaping detection — and remain undetectable until they collide with something beyond their expected range.

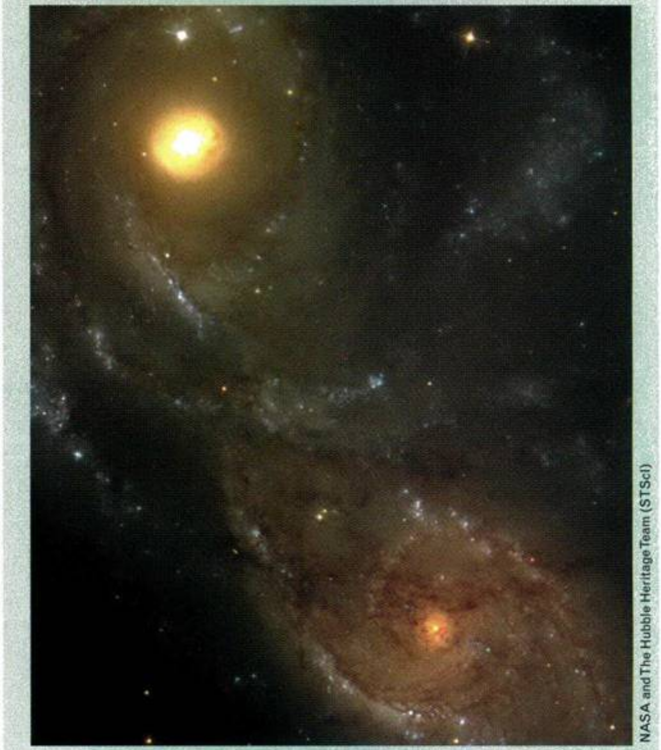
"Outflowing material has been traced more than 30,000 light-years from the nucleus along the minor axis of M82," says Patrick Shopbell, an astronomer at the University of Maryland in College Park. Data also imply that galaxies may drag their superwinds with them, causing reactions with the IGM along the way, Shopbell says. These reactions increase the visi-



Patrick Shopbell (University of Maryland), et al., NASA

Superwinds may power the streams of material shooting from above and below the main axis of M82, shown in this recent Hubble Space Telescope image.

CLOSE ENCOUNTERS



NASA and The Hubble Heritage Team (STScI)

TWO SPIRAL GALAXIES IN THE DIRECTION OF CANIS MAJOR are brushing past each other, causing distortions in the smaller of the two. NGC 2207, the larger galaxy on the upper left, pulls and tugs at IC 2163, which trails stars and gas out to its side in a swath more than 100,000 light-years long. The tidal interactions of the galaxies are strong enough to someday pull the galaxies back toward each other. Billions of years from now they will merge into a single galaxy. The galaxies, which in this Hubble Space Telescope image look like the glowing eyes of a frightening mask, appear as two nearly colliding, whirling galactic wisps. You can find this pair on February evenings; from the Northern Hemisphere look south with the help of a good star chart and a powerful telescope and you'll spy the 11th-magnitude pair.

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bility of superwinds. Heckman readily concurs.

"The superwind cools as it flows outward until it hits a gas cloud," says Heckman. "The collision reheats everything and the blob of gas becomes visible again," he says. Superwinds that become recharged this way often blast themselves beyond their own galaxy.

"We strongly suspect that much of the metals present in the IGM are due to galactic winds that have slowly dispersed over time," Shopbell says.

Astronomers find superwinds wherever they discover an area of intense starburst activity. Other starbursting galaxies, such as the spiral galaxy NGC 253, the dwarf galaxy NGC 1569, and the ultrapowerful starburst Arp 220, also display the superwind phenomenon, says Heckman. Weaker superwinds manifest themselves in nonstarburst galaxies also. Learning the details of superwind formation is key to furthering astronomers' understanding of the universe and "changes the conception of how stars affect both the galaxies in which they are born and the IGM," Heckman says.

Recent studies comparing variations in overall star-formation rates in galaxies with increasing redshift measurements strongly hint that superwinds flowing out of young galaxies may have played an integral role in the early history of the universe.

Nuclear furnaces of massive stars are known to create heavy elements. How those heavy elements disperse throughout the universe remains a mystery.

Perhaps the answer is blowing in the superwind.
— Carol Ryback

HIDDEN GIANT

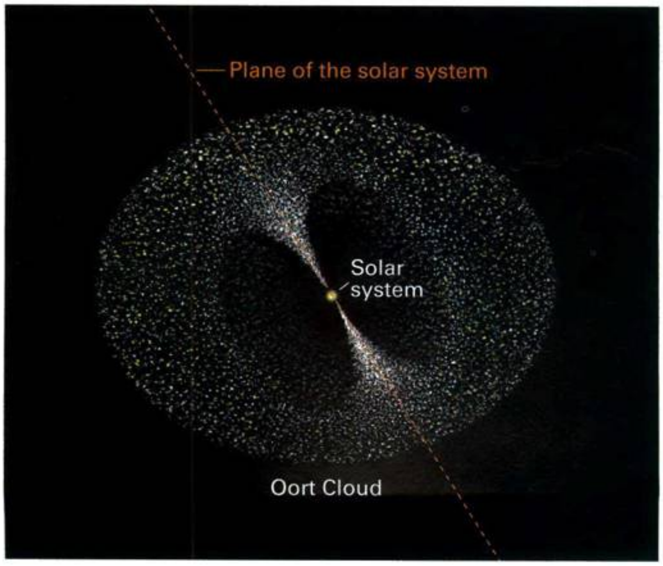
Solar System May Possess 10th Planet

▶ British and American astronomers independently have found evidence of a possible 10th planet — a body perhaps three times the mass of Jupiter — which may jostle comets as it lumbers unseen in the frozen outer realms of the solar system. The evidence is indirect, inferred from the paths of comets that careen inward toward the sun. The astronomers found a pattern in the points of origin of the comets within the Oort Cloud, the vast spherical reservoir containing trillions of comets extending as far as 1 to 2 light-years from the sun.

Studying the orbits of 13 comets, John Murray of the Open University in Milton Keynes, England, found that they descended from a great arc across the Oort Cloud. By his calculations, an unseen object orbits the sun at a distance of perhaps 3 trillion miles and is inclined from the plane of the innermost eight planets. (Pluto's orbit is inclined 17° from the ecliptic.) Murray's calculations, reported in *Monthly Notices of the Royal Astronomical Society*, also leave open the possibility that the planet could have been captured from interstellar space.

Physicists Daniel Whitmire and John Matese of the University of Louisiana in Lafayette have reached a similar conclusion. Of 82 cometary orbits they studied, their calculations showed that 22 had descended from a great arc across the sky, possibly caused by the gravitational handiwork of a hidden giant. The American scientists say the unseen perturber of the comets may be a brown dwarf, or failed star, in a binary system with the sun. Whitmire and Matese report that the mysterious object orbits the sun on a path that is inclined 30° from that of the innermost eight planets. They reported their results in *Icarus*.

But there are skeptics. "I wouldn't be so hasty," says astronomer Brian Marsden of the Harvard-Smithsonian Center for Astrophysics in Cambridge, Massachusetts. He adds that the presumed orbits of the comets studied thus far are imprecise because they are based on brief observations. Before a 10th planet can be added to our planetary family, more comets must be studied, he says. But even if the astronomers' calculations are correct, Marsden says a star that passed eons ago might have kicked loose the comets. — David Graham


Plane of the solar system
Solar system
Oort Cloud

The Oort Cloud may contain more than comets. *Astronomy:* Elisabeth Rowan

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Bob Morrow, at Orbital Technologies Corporation in Madison, Wisconsin, found his company's ticket to Mars in the forest products lab at the University of Wisconsin. Researchers there found a way to build things with molded wood fiber.

That might seem out of place on a solar system voyage, but Morrow, a plant

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M16 Nebulous Star Cluster. This extended object consists of a large scattered star cluster immersed in a vast diffuse nebula. The major dark projection is a sharply outlined dust cloud. In this nebula we are seeing a cloud of hot gas expanding into cooler gas, and the hot gas is expanding outward like an exploding bomb. Many smaller nebulae are scattered across the face of the bright cloud. The estimated distance is about 8,000 light years which places it in the great Sagittarius spiral arm of the Galaxy. At this accepted distance the actual diameter is about 70 light years with the bright central region about 25 light years. This remarkable 300 second ST-7 CCD image was taken through a 7", f/7 Astrophysics refractor utiizing the self-guiding mode. *Courtesy Tony Hallas.*

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scientist, points out that any Mars base will need a self-contained farm.

Morrow is trying to develop an alternative to peat pots sold by plant nurseries. You'd have to fly a lot of peat pots to Mars, but Morrow's company believes travelers to Mars could mold new seed-support structures out of the plant waste from last year's martian garden.

On the other end of the metabolic cycle, Atwater's company is trying to find a new way to break down some of the nastier compounds found in the inevitable human-waste stream. Working in the woods of central Oregon, Umpqua wants to build a room-temperature device to clean things out of water that most of us would prefer to flush away.

If way-off-road bicycling grabs you, you might want to visit the researchers at J.B. Witmer Company in Arroyo Grande, California. Witmer engineers, who develop precision mountain-bike racing parts, are turning their attention to the problem of keeping astronauts fit with the "G-Cycle Hyper-Gravity Exerciser." — John Fleck

SATELLITE RIVAL

Innovative Balloon Design Holds Promise

▶ In late October 1999, NASA tested a new helium-balloon prototype, a full-sized version of which may someday serve as a near-space platform to launch research missions and test experimental equipment. Called an Ultra Long Duration Balloon, or ULDB, the new design features multiple longitudinal ridges that distribute stress evenly throughout its structure. ULDB Project Manager Steve Smith of the Goddard Space Flight Center's Wallops Flight Facility says the one-tenth sized prototype carrying a 1,640-pound payload launched smoothly from Fort Sumner, New Mexico. The craft reached an altitude of about 16 miles and accomplished 90 percent of its objectives before a reinforcing tendon attached to the balloon skin slid out of position, causing the balloon to fail. Engineers recovered the balloon about 40 miles from the launch site. Smith believes that a simple readjustment to a tendon-locking mechanism will prevent such problems on future flights.

Launch of the Ultra Long Duration Balloon prototype in October 1999. NASA

Under development since 1997, the ULDB's closed-gas system and advanced materials allow it to lift heavier payloads than other balloons. The composite material, manufactured by Dimension Polyant of Putnam, Connecticut, and fabricated into a balloon by Raven Industries of Sioux Falls, South Dakota, features a triple-layer blend of polyesters and polyethylenes bonded together by two soft adhesive layers. As the adhesive melds with the polyethylene and realigns the fabric fibers, it compensates for weave defects and changing atmospheric conditions, creating a nearly impervious barrier between the helium bubble and the atmosphere. The closed-system design permits the ULDBs to remain aloft for up to 100 days — versus two or three days for conventional open-system balloons.

"This presents an opportunity for what I like to call 'ton-class' missions using balloons, which will make us very competitive with smaller satellite missions," says Vernon Jones, senior science program executive in the office of Space Science at NASA headquarters. Jones foresees other practical applications for ULDB technology, including near-space science missions with balloons functioning as platforms for research and future planetary missions that will deploy balloons to do experiments. Launch of a full-scale ULDB from New Zealand is scheduled for December 2001. Washington University in St. Louis, Missouri, will provide the TIGER (Trans-Iron Galactic Element Recorder) science payload. TIGER 2001 will verify the feasibility of someday using ULDBs during missions to Mars or other destinations.
— Carol Ryback

DISTANT STRANGER

Another Oddity in Deep Space

▶ Astronomers focusing on a dim, supposedly boring patch of the southern sky have found a new type of energetic galaxy about 10 billion light-years from Earth that crackles with radio emissions. Dubbed radio "Source C" in the Hubble Deep Field-South, the now intensely studied region of the southern sky, the galaxy is forming new stars at a high rate within a cloud of gas and dust.

What sets the galaxy apart from any other galaxy found to date is its huge amount of radio emissions relative to its visible-light output: Source C's radio-optical ratio is 1,000 times greater than any known object in the local universe. "It's pretty strange," says Ray P. Norris, an astrophysicist at the Australian Telescope National Facility and codiscoverer of the galaxy.

The object was first noted in 1998 simply as a dim and somewhat elongated galaxy in the Deep Field-South image. Robert E. Williams, then director of the Space Telescope Science Institute, led a team that took a 10-

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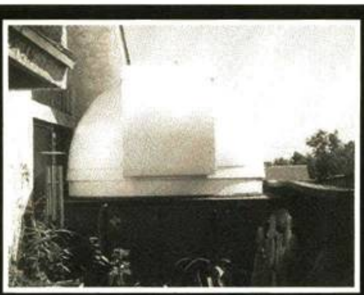

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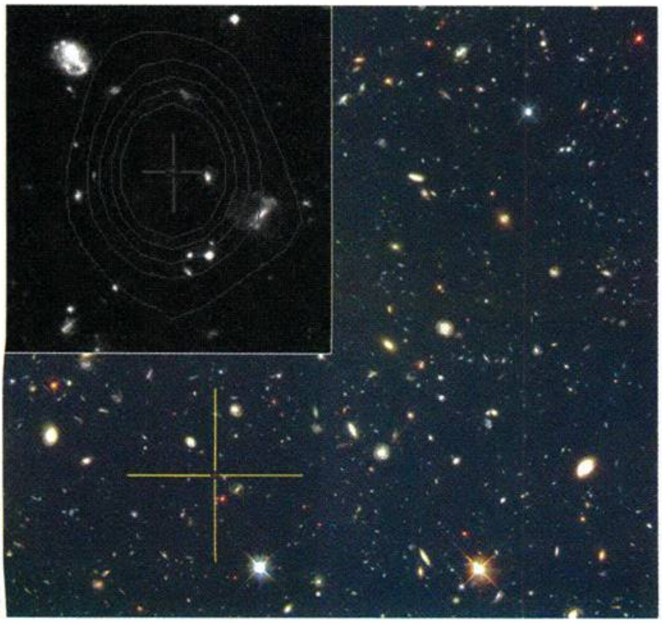
hour exposure of a specifically unremarkable speck of southern sky with the Hubble Space Telescope. Williams's goal was to compare a long-exposure image of the southern sky with a similar one taken in 1995 of the northern sky that contains about 1,500 galaxies down to 30th magnitude. At first, astronomers found no obvious differences between objects in the north and south images. However, when Norris's team made radio-wave observations of the southern region with the Australian Telescope Compact Array, Source C emerged as an oddball.

Additional observations may show that Source C resembles a less luminous radio galaxy in the Deep Field-North region. "These two sources may still be related, with Source C being more extreme," says Norris.

In 1999, the most distant galaxy ever seen — one that may have formed less than 1 billion years after the Big Bang — was reported in the Deep Field-North region. The discovery was made with follow-up observations by the W. M. Keck Observatory in Hawaii. Astronomers using Keck and the Kitt Peak National Observatory in Arizona also spotted in 1999 what may be a primordial galaxy that formed shortly after the Big Bang.

The possible "protogalaxy" is deeply reddened — either because of the effects of intervening dust or simply because of its great distance from Earth. The protogalaxy is forming stars at a colossal rate — estimated to be equivalent to about 100 solar masses per year.

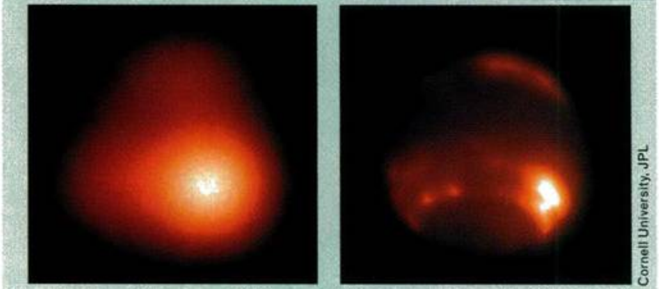
"These discoveries certainly indicate that exciting objects can turn up when there is a concerted effort by all the astronomers of the world focused on particular parts of the sky," says Douglas Scott, an astronomer at the University of British Columbia in Vancouver. Those concerted efforts by dozens of astronomers are continuing.
— Rex Graham



The radio-bright "Source C," top left, looks unremarkable in the Hubble Deep Field-South observation, bottom.

Ray P. Norris, STScI, NASA

HALE ENLIGHTENMENT



Cornell University, JPL

NEPTUNE WAS THE FIRST TARGET for a new infrared camera built by Cornell University researchers and installed on the 200-inch Hale Telescope at Palomar Observatory in California. The camera, named PHARO for Palomar High Angular Resolution Observer, receives light from a new adaptive optics (AO) system. The AO technology corrects for atmospheric turbulence to produce images with detail that is near the maximum theoretically possible with the mirror. Cornell astronomer Don Banfield took the images on August 29, 1999, without adaptive optics, left, and with, right. The corrected image shows a cloud the size of Europe and many smaller ones. PHARO's next target will be Titan, the largest of Saturn's 18 known satellites and the only moon in the solar system with a substantial atmosphere.

BLACK-HOLE RIDDLE

Magnetic 'Sleeves' May Encircle Cosmic Jets

▶ Nobody knows exactly how huge geysers of charged, high-speed particles called "jets" arise in the cosmos. However, researchers are coming closer to understanding them thanks to some of the most detailed astronomical observations ever made. Evidence suggests that accretion disks spinning at high velocity around black holes can sometimes form such jets.

Radio astronomers from the University of New Mexico in Albuquerque and from the Space Telescope Science Institute in Baltimore, Maryland, obtained detailed images of a jet that supports that view. The team, which reported its latest results in *Nature*, observed the region at the base of a jet close to a black hole at the center of galaxy M87.

Jets shoot out of the centers of many active galaxies and quasars. Jets also appear briefly when stars collapse as supernovae, and some astrophysicists believe that at least some produce gamma-ray bursts that are observable if they are directed toward Earth. These jets consist mainly of electrons and positrons, which emit light and radio waves as magnetic fields accelerate

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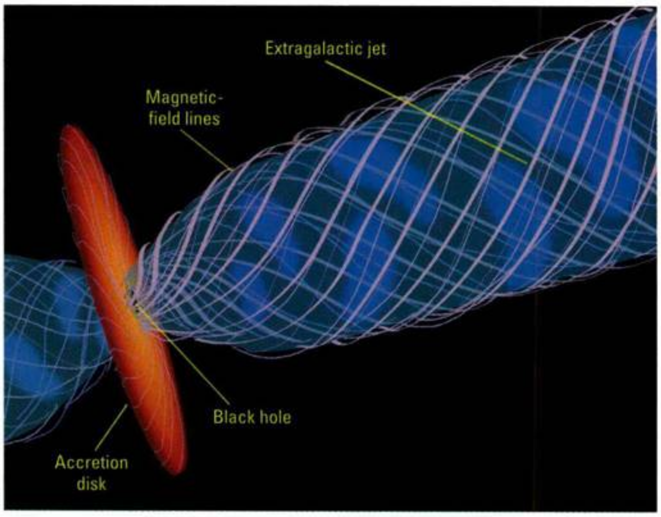

NRAO

This is an artist's concept of how extragalactic jets originate at accretion disks of black holes and are sculpted by magnetic-field lines.

them to nearly the speed of light. Radio images of M87 at the center of the Virgo Cluster show that its jet spans an angle of 60° near its point of origination next to the black hole. However, the energetic jet somehow stops spreading at greater distances from the black-hole source.

The architectural details were revealed in images of M87 that have incredibly sharp resolutions of roughly 0.2 milliarcsecond. "This is about 500 times better than what you can get with the Hubble Space Telescope," says John Biretta of the Space Telescope Science Institute. Astronomers created the images with observations involving the Very Long Baseline Array, the Very Large Array, and radio telescopes in Europe.

"We see the jet being formed and collimated from a very broad flow to a much narrower flow that is seen farther out," says Biretta. This is happening at a scale about 100 times larger than the size of the event horizon of the black hole, which is believed to be the approximate size of the accretion disk. "This is a very important piece of information," says Roger Blandford of the California Institute of Technology. In the 1980s, Blandford and Mitchell Begelman of the University of Colorado developed a theory for the formation of cosmic jets.

Their theory said an accretion disk spinning close to the speed of light generates a strong magnetic field that wraps itself around the jet and provides a "sleeve" that collimates the outflow. Although recent observations seem to be consistent with this theory, uncertainties remain about the details. Blandford says astrophysicists will use large-scale computer models that incorporate general-relativity equations to test his theory.

Astronomers also are awaiting images from the Chandra X-ray Observatory, which will examine a number of x-ray jets. Chandra earlier obtained stunning images of a jet associated with Centaurus A, a nearby galaxy noted for its explosive activity. — ALEXANDER HELLEMANS

Very Large Telescope Probes Mysteries of Starburst Region

An international group of astronomers has imaged small, newborn stars in an emission nebula in the Milky Way called NGC 3603 with the European Southern Observatory's (ESO) Very Large Telescope (VLT) at Paranal, Chile. Until now, it has only been possible to observe brighter and much heavier stars in such nebulae. The new observations show that stars of all masses are being born together in the same starburst event, a fundamental result for understanding the very complex process of star formation. For more, go to www.astronomy.com/horizon.html.

Small stars are visible near large ones in starburst region NGC 3603.

Bernhard Brandl, et al., ESO

Antarctica Mapped in Stunning Detail from Space

RADARSAT, a Canadian satellite, has taken high-resolution images of Antarctica that are sharp enough to pick out a research bungalow on an iceberg. Images of eastern and western Antarctica revealed dunes of snow more than 6 miles (10 km) long. The new map has answered some of scientists' questions about the icy continent but left them wondering what to make of many strange and fascinating features never seen before. "This map is truly a new window on the Antarctic continent, providing new beginnings in our Earth science studies there," says NASA Earth scientist Ghassem Asrar. The new map was produced as part of NASA's Antarctic Mapping Project. For more, go to www.astronomy.com/horizon.html.

Eastern and western parts of Antarctica are home to vast dunes of snow.

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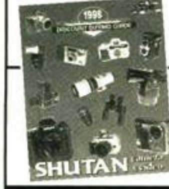

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CELESTAR 8 TELESCOPES

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- Perfect for a first time astronomer.
- An economical but full featured 8" (2032mm f/10) Schmidt-Cassegrain. A considerable amount of engineering work went into the design of the Celestar 8.
- No sacrifice was made in the optics. Celestron's carefully hand-figured system delivers diffraction-limited optics of unsurpassed quality. Starbright® coatings are standard.
- The energy efficient DC electronics are powered by a 9 volt alkaline battery for easy astronomy on the go.
- The totally cordless electronics have a built-in drive corrector which is activated when using the optional hand control. The R.A. motor's main tracking speed is an accurately regulated sidereal rate. The optional hand control allows for fast and slow override of R.A. tracking speed and ± operation of the optional DEC motor. A comment from the Sky & Telescope review – "the digital electronics delivered a near-perfect sidereal tracking rate."
- The Celestar 8 drive can operate in the Northern or Southern hemisphere from 0° to 90.°
- The unique Wedgpod is a combination tripod and wedge which is very stable.
- Made in the U.S.A.
- Standard accessories include: 6x30 Finderscope, Star Diagonal – 1¼" and a 25mm SMA Eyepiece – 1¼" (81x).
- Weight – 41 pounds.

CELESTAR 8 DELUXE

- For the more serious astronomer.
- This telescope utilizes the same superior optics and has all the features of the Celestar 8, but is enhanced, for those who prefer a premium version.
- This model has a heavier duty fork mount and drive base, with a precision worm gear drive system.
- Superior tracking accuracy is attained with this advanced drive system, which has four tracking rates and PEC (Periodic Error Correction).
- For the kind of versatility that makes observing a pleasure, the hand controller makes available a micro guide rate of .5x sidereal and a slew rate of 8x sidereal.
- The stepper motor drive electronics are cordless and operate on two 9 volt batteries.
- The Celestar 8 Deluxe has many features that are necessary for the more serious amateur astronomer, particularly if you're interested in astrophotography or CCD imaging with the PixCel or other CCD cameras.
- Fastar compatible for f/1.95 CCD imaging – deep sky images in 30 seconds or less!
- Made in the U.S.A.
- The standard accessories for this telescope include: Declination Motor, Car Battery Adapter, Hand Controller, Wedge and a Tripod with adjustable height that's exceptionally rigid and sturdy .
- Also standard is a large 9x50 Finderscope, Star Diagonal – 1¼" and a multi-coated 26mm Plossl Eyepiece – 1¼" (78X).
- Weight – 52 pounds.

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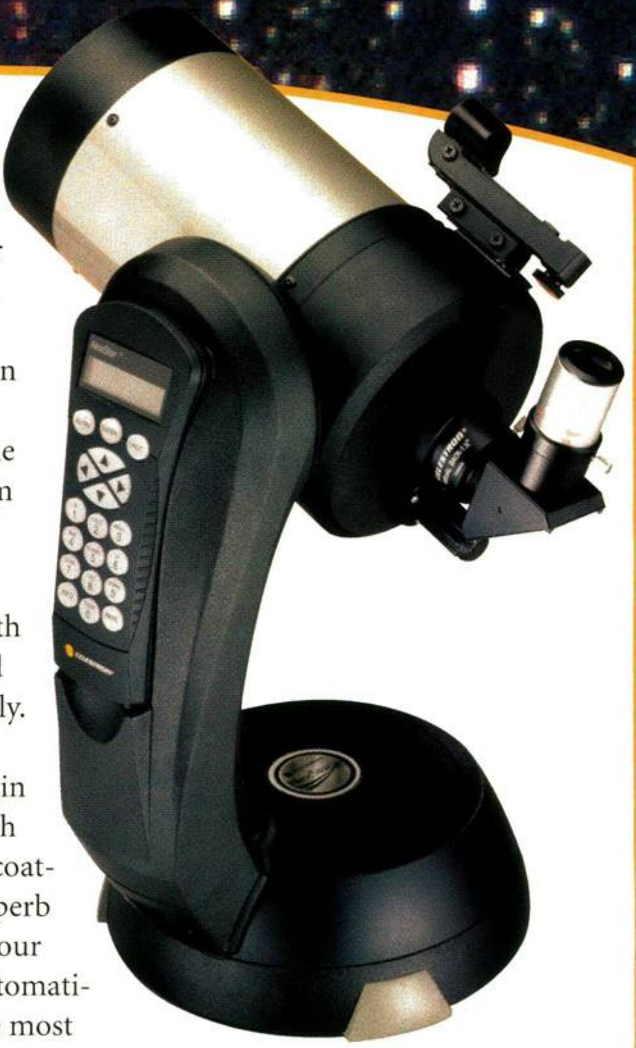

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All models come standard with a 6x30 finderscope and a premium 20mm Plössl 1¼" eyepiece.

OPTICS – all **HD** series telescopes have diffraction limited, premium optics manufactured to Celestron's uncompromising standards. The star images are classic textbook Airy disks. The Newtonians have multicoated optics and the refractors are fully multicoated to provide higher light transmission yielding bright, high contrast images.

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MOUNT AND TRIPOD – the **HD** telescopes use the CG-4 German equatorial mount. It is a precision, heavy-duty mount which is upgraded and much better than the older polaris mounts.

The precision worm gears are extremely smooth in motion and the tracking accuracy is excellent. Optional motor drives make astrophotography easy and fun.

The tripod is a sturdy, adjustable height unit made of aluminium and it includes a heavy-duty accessory tray.

In addition, the 102mm refractor is offered with a **HD** altazimuth mount. This mount is easy to use and has slow motion controls (flexible cables) on both axes to allow for quick and easy pointing and tracking.

The superb optics with rigid mount and tripod of the **HD** telescopes allow you to enjoy awesome details of our moon such as craters, rills and mountain ranges; Saturn and its rings; Jupiter with its belts and moons; Mars, Venus and Mercury; deep-sky objects such as galaxies, nebulae, double stars and star clusters.

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They are the perfect sky-watching tools for amateur astronomers of all levels. Whether you're a first time user or a seasoned cosmic observer, you will appreciate the bright images, sharp contrast and exquisite detail provided by Celestron's legendary U.S.-made optics. Meticulously hand-crafted for optical excellence, the **G-3** and **G-5** are manufactured under strict quality standards.

OPTICS:

- **G-3** - 3½" aperture, 1000mm f/11
- **G-5** - 5" aperture, 1250mm f/10

The **G-3** (Maksutov-Cassegrain optical design) and the **G-5** (Schmidt-Cassegrain optical design) deliver razor sharp images over a wide field. They both feature Celestron's world renowned hand-figured diffraction limited optical systems. Starbright® optical multicoatings provide maximum reflectivity and increased light transmission.

MOUNT AND MOTOR DRIVE

An ultra-durable German equatorial mount is standard on the **G-3** and **G-5**. Setting circles and slow motion controls make it easier to locate and track objects manually. Setup is a breeze with the adjustable height aluminum tripod complete with deluxe accessory tray.

Automatic tracking of celestial objects is yours with the dual speed, single axis motor drive models as pictured above. A hand controller makes observing more fun as objects are easier to center. The built-in drive corrector, which runs on 4 "D" batteries, makes astrophotography possible. Non motor driven models are also available.

STANDARD ACCESSORIES

A 25mm SMA eyepiece - 1¼" (40 power - **G-3**/50 power - **G-5**) is included. The **G-3** includes an 8x20 erect image finderscope and the **G-5** has a 6x30 finderscope.

A fun and educational CD-ROM, "The Sky Level 1 for Celestron," features a 10,000 object database and allows you to print your own custom sky charts.

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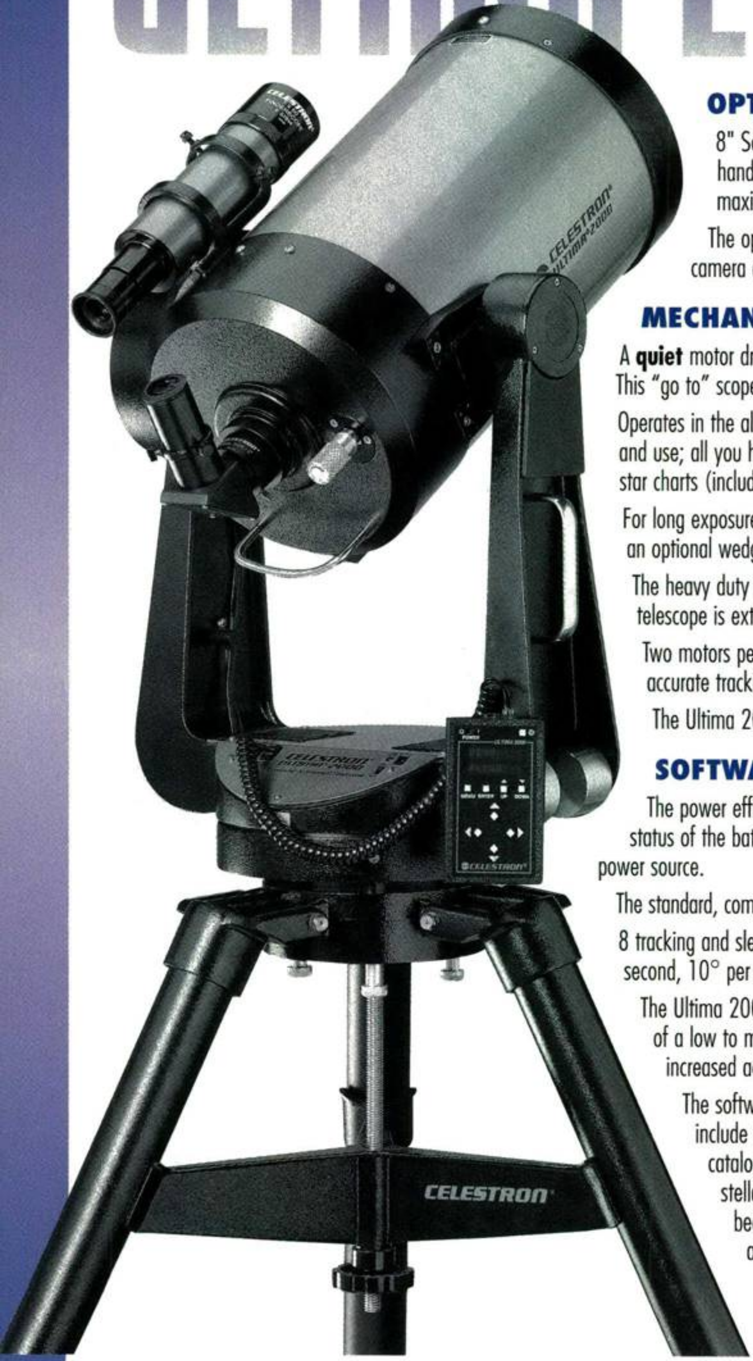

OPTICS

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The optics are Fastar compatible which provides the potential for CCD imaging using the PixCel CCD camera at an incredible f/1.95! Deep sky images in 30 seconds or less.

MECHANICAL FEATURES

A **quiet** motor driven "go to" computerized telescope built entirely at the Celestron factory in Torrance, California. This "go to" scope won't disturb your neighbors.

Operates in the altazimuth configuration allowing you to find most objects in seconds. Simple to set up and use; all you have to do is find two alignment stars which are easily located on the laminated monthly star charts (included).

For long exposure astrophotography or CCD imaging, use the telescope in the equatorial configuration by adding an optional wedge.

The heavy duty fork mount is extremely rigid and sits on top of a sturdy, adjustable metal tripod. Yet, the telescope is extremely portable and convenient to take with you.

Two motors per axis are standard as well as precision worm gears in both axes that provide very smooth, accurate tracking ability.

The Ultima 2000 can be moved manually (by hand) without losing its star alignment.

SOFTWARE/ELECTRONICS FEATURES

The power efficient DC telescope is operated with the included AA batteries. A built-in voltmeter monitors the status of the batteries. Optional adapters are available to run the telescope from a car battery or from an AC power source.

The standard, compact hand controller operates the various functions such as position, identify, speed, pointing, etc.

8 tracking and slewing speeds are available – sidereal, solar, lunar, King, 2x sidereal, 0.5x sidereal, 2° per second, 10° per second.

The Ultima 2000 has impressive pointing accuracy where the object selected will always be in the field of view of a low to medium power eyepiece. Includes Enhanced Encoder Resolution and Relative Go To mode for increased accuracy which is ideal for centering objects on a CCD chip.

The software database contains over 10,000 deep-sky objects as well as major planets. The objects include the entire Revised New General Catalog, the Messier catalog, selected objects within the IC catalog and the ESO and Uppsula catalogs, 241 interesting double and multiple stars, and 661 non-stellar objects. The database may not be the largest in the industry but it is one of the most useful because of the object selection. In addition, the display of the object data is the most complete of any commercial computerized telescope.

For beginners and educators, a special Tour mode is available which allows you to view 15 popular objects by season, automatically.

To quickly and easily find your favorite objects, the telescope offers 25 user-defined selections.

The Ultima 2000 can by operated by a computer using popular astronomy software such as *The Sky*. Programs can also be written by the user to control the telescope.

Other standard features and accessories include: 9x50 finderscope, multi-coated 26mm Plössl eyepiece – 1¼" (78x), star diagonal – 1¼", LED display, auto guider port, northern and southern hemisphere operation, comprehensive instruction manual.

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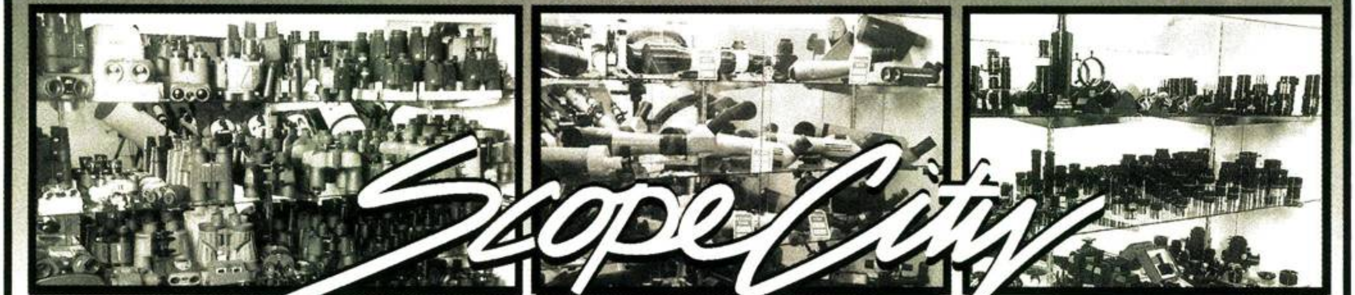

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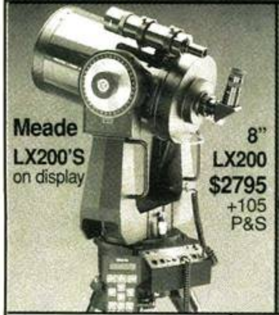

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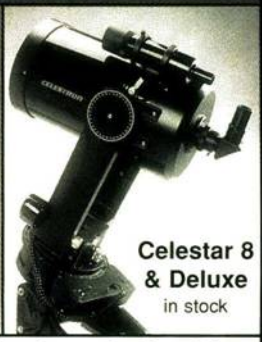

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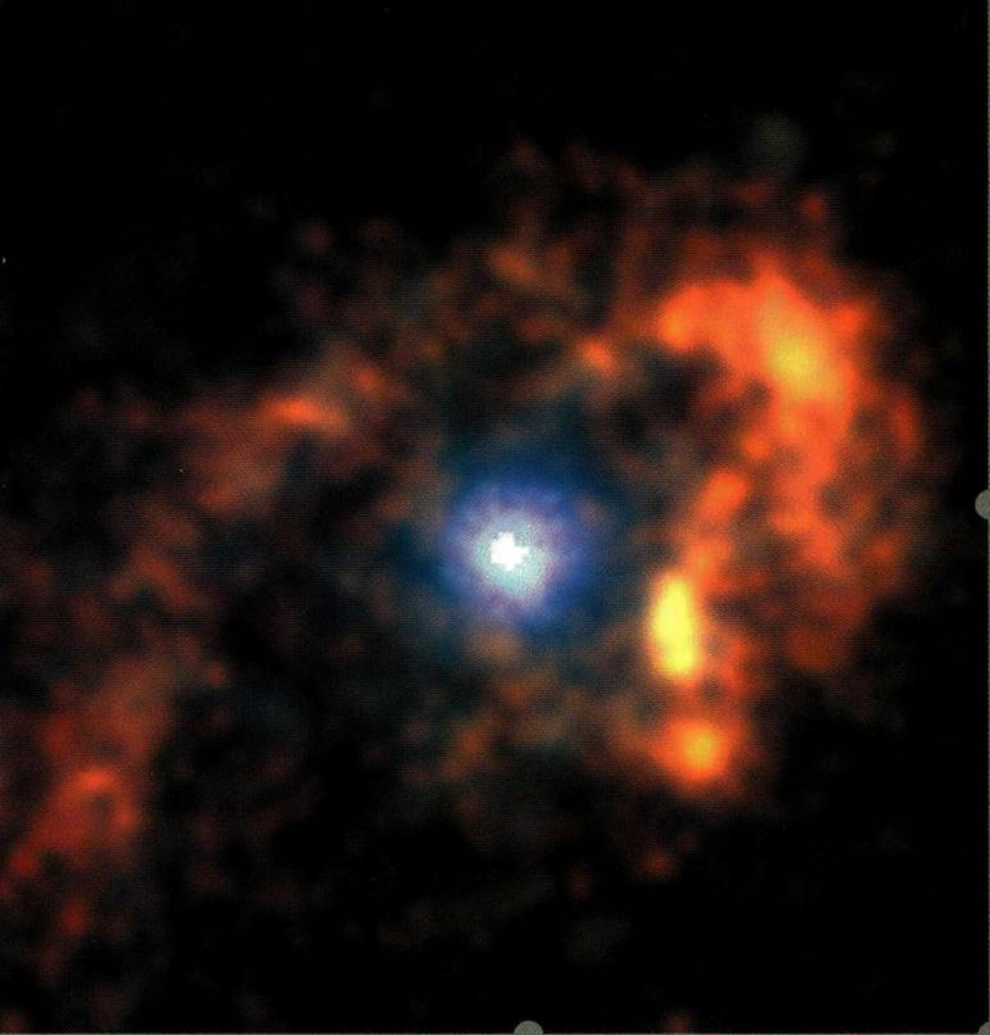
SCOPING OUT THE MONSTER STAR

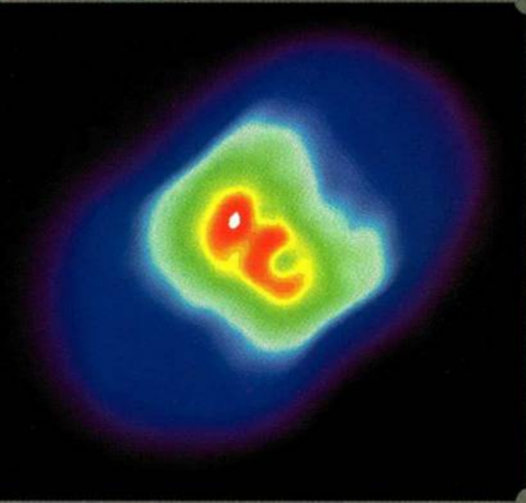
Eta Carinae — the biggest, baddest star in the Milky Way — has started brightening again, and no one knows why or where it might lead.

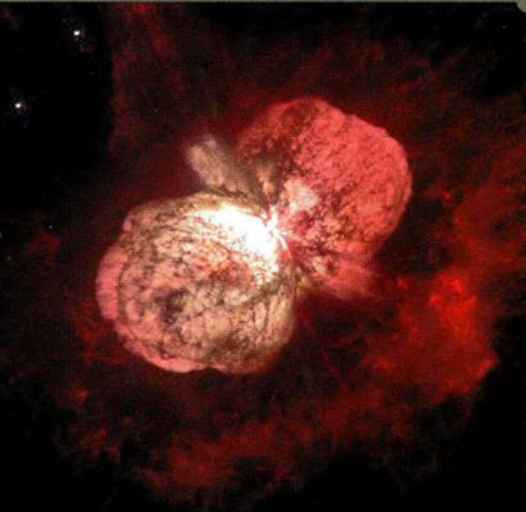
by Robert Zimmerman

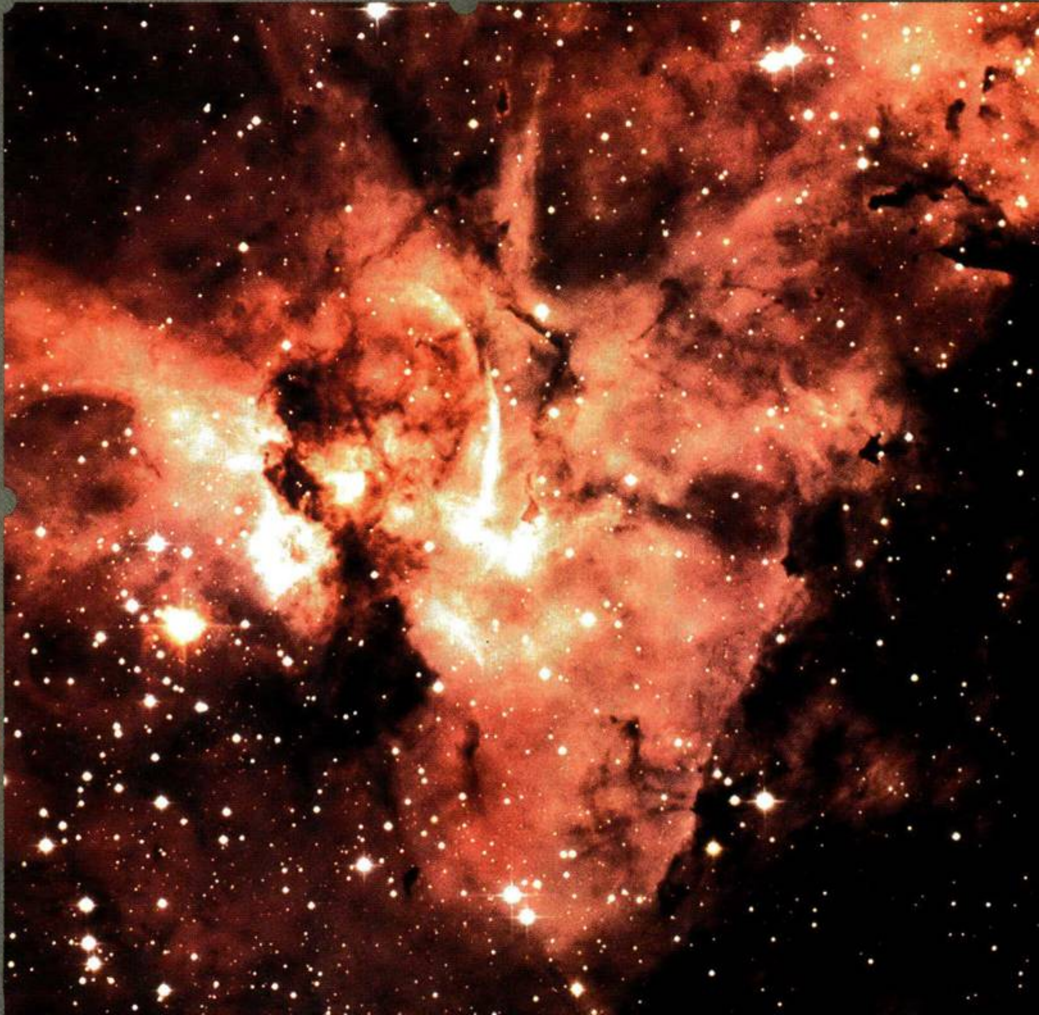
LIKE A KING, THIS GIGANTIC STAR IMPERIOUSLY ORDAINS THE life and death of all its neighbors. Some stars it feeds, providing the complex molecular material used by newborn stars to coalesce and form. Others it annihilates, exterminating any life that might dwell within nearby stellar systems.

The star shines so brightly that it would appear as bright as the sun does in our sky from 185 billion miles away — some 50 times the distance to Pluto. With about 120 times the mass of the sun, it comes close to the theoretical limit of how big a star can be. And although it lies 7,500 light-years away, the star glittered more brilliantly than any other star in the Galaxy between approximately 1835 and 1855. During this 20-year Great Eruption, it spit out two to three suns' worth of material.









The star is Eta Carinae, considered by many astronomers to be the brightest object in the Milky Way Galaxy and among its heaviest. It is also one of the strangest and rarest of stellar bodies — a gargantuan variable star that fluctuates in an irregular and completely unpredictable manner.

Today Eta Carinae remains luminous and unstable, surrounded by one of the most beautiful and distinct nebulae in the heavens. Moreover, astronomers were astonished recently when — without any warning — it suddenly began to brighten again at all wavelengths. In the past year its brightness has more than doubled, leaping upward so that the star and its surrounding nebula now glow around 5th magnitude, the brightest in more than a century.

One hundred and fifty years ago, the English amateur astronomer John Herschel asked: "What origin can we ascribe to these sudden flashes and relapses?" His question remains unanswered, no doubt in part because this regal star continues to be cloaked by dusty clouds. In fact, astronomers are not even sure if Eta Carinae is a single star. To paraphrase Winston Churchill, Eta Carinae remains "a riddle wrapped in a mystery inside an enigma."

Yet, Eta Carinae's place in stellar evolution is crucial. Its mysterious behavior challenges every theory that tries to explain the life and death of stars — including our own sun. Its future activity might even tell us why, where, and when other stars go boom.

THE GREAT ERUPTION

Kris Davidson of the University of Minnesota has said that Eta Carinae "is to the Southern Hemisphere what the Crab Nebula is to the north." Until the third decade of the 19th century, however, Eta Carinae was considered an unusual but undistinguished variable star, sometimes glowing at 4th magnitude, sometimes at 2nd. Then in the 1830s, John Herschel noticed that the star's light had risen steeply and, by December 1837, had reached 1st magnitude. Puzzled by this strange jump in brightness, Herschel researched the history of the star and discovered that it had also reached 1st magnitude in 1827 and again in 1832. After fading in 1838, the star blazed forth in 1843, zooming to a magnitude of –1 and becoming, for a short period, the second brightest star in the sky, eclipsed only by Sirius.

For the next twenty years, Eta Carinae remained among the sky's most brilliant stars, fading in fits and jerks until it finally dropped below naked-eye visibility in 1868, stabilizing at about 7th magnitude. In 1889 the star brightened for a short while, barely reaching 6th magnitude, then settled back down to a relatively quiet, stable glow around 8th magnitude for the next few decades.

In recent years, Eta had been growing slowly brighter, rising almost a full magnitude from 1950 to 1992. During this period scientists continued to puzzle over the star's nature. Though ground-based photographs showed that Eta was surrounded by a rapidly expanding cloud that could be traced back to the Great Eruption of 1843, the resolution of the images wasn't high enough to ascertain the exact structure or learn how the cloud interacted with the star. Because its shape resembled that of a human, Enrique Gaviola of the Cordoba Observatory in Argentina dubbed this nebula the Homunculus, which means "little man."

Then in 1994, the Hubble Space Telescope received a set of corrective lenses, and Eta Carinae became one of the first targets for the newly repaired telescope. The stunning image unveiled a star erupting. Suddenly, after centuries of unclear vision, scientists and ordinary citizens could look at the nebulosity surrounding the star and see its shape and detailed structure.

THE HOMUNCULUS

The most obvious features in the Hubble images are the two large and grayish bipolar lobes, shaped somewhat like an hourglass. With a total mass somewhere around three times that of the sun, their glow comes mainly from starlight radiated by Eta Carinae that reflects off the ubiquitous dust in the lobes. Ejected from the star during the 1843 eruption, each lobe is expanding outward at the rate of about 1.5 million miles per hour. At this great speed — fast enough for a spaceship to travel to the moon and back three times in an hour — the lobes have expanded in 150 years to span about four trillion miles, or some 0.7 light-year.

In all likelihood, the lobes are mostly hollow, though astronomers have detected evidence of some dust within them. No one knows whether the lobes are shaped like spheres or cones. Either way, they apparently formed when matter was ejected from the star's polar regions. Perhaps this happened because Eta Carinae spins rapidly, possesses a powerful magnetic field, belongs to a binary star system, or some combination of these factors. Regardless, the ejecta from the 1843 eruption had a harder time escaping from near the equator and was forced to seek the path of least resistance, traveling outward from the poles.

Less obvious but also seen first in the Hubble images was the strange equatorial disk tilted between 52° and 60° to our line of sight and about 90° to the two lobes. Faintly resembling a ceiling fan with many blades, the disk consists of many curious objects moving at a wide range of speeds. Three mysterious blobs appear embedded within the disk only a few light-days (about fifty billion miles) from Eta. Flying outward from the star at about 100,000 miles per hour, all three seem arranged around the outside edge of the equatorial disk's largest fan (called the Paddle and visible as the triangular-shaped bright area above and to the right of the Homunculus's center). Astronomers don't yet know what caused these blobs to erupt from the star so asymmetrically, though their speed and distance from the star suggest they were ejected in 1889.

Within the Paddle itself, however, several small regions move at much slower speeds, as low as 30,000 miles per hour. These relatively sluggish speeds imply that the features were ejected from Eta several hundred years ago, long before the eruptions of the 19th century.

The equatorial disk also contains several mysterious and fast-moving jets, or "bullets" as some scientists have labeled them. The northern jet is

Previous page, clockwise from top left: X-rays reveal gas glowing at millions of degrees; the horseshoe-shaped ring spans two light-years, while Eta itself apparently lies hidden in the central blue cloud. NASA/CXC/SAO **A wide-field view in visible light shows the entire Eta Carinae Nebula and its surroundings.** Luke Dodd **The nebula glows with a reddish hue characteristic of hot hydrogen gas.** Michael Stecker **Numerous stars, gas, and dust lie in the immediate vicinity of Eta.** ©1984, Anglo-Australian Telescope Board **Hubble's view of the Homunculus Nebula reveals material thrown off in the 1843 Great Eruption.** NASA/STScI **The warm, dusty surroundings of Eta show up best at infrared wavelengths.** Elisha Polomski (University of Florida/CTIO)

Eta Carinae itself lies hidden among the rich gas and dust just north (above) of the bend in the dark wedge at center. Luke Dodd

shooting away from the star at a tremendous velocity, estimated as high as 3.4 million miles per hour. As it rockets outward it appears to be pushing its way through the interstellar medium of nitrogen gas that surrounds Eta Carinae and was ejected in a much earlier, unrecorded eruption. Although some scientists believe that the jet's origin is linked to the 1889 eruption, others contend that it — along with most of the equatorial disk — formed during the Great Eruption of 1843.

In fact, all the data gathered about the equatorial disk so far presents scientists with an exceedingly confusing picture of its origin. Depending on when and where they look, different astronomers get different results. Perhaps Ted Gull of NASA's Goddard Space Flight Center puts it best when he says "the disk appears to be the accumulation of many outbursts."

Even more baffling is the disk's odd radial appearance, with its fans, spokes, and jets all pointing toward the star. As Davidson and Roberta Humphreys, also at the University of Minnesota, have written, "We regard the radial streaks as warning arrows pointing inward toward some extraordinary phenomenon near the central star."

SUPER SIZED

Finding out the nature of that phenomenon, however, has proven difficult. Although astronomers regard Eta Carinae as one of the largest and brightest stars in the Galaxy, it has never been viewed directly, hidden as it is within the gigantic cloud that surrounds it. In fact, the star's dusty lobes prevent scientists from even knowing the exact duration of the Great Eruption, which might have continued long after the star had faded to 7th magnitude in 1868. As the lobes were spewed outward they drew a curtain on the eruption, making it appear as if the fireworks had ended, when in truth they could have continued for years.

What astronomers do know about Eta Carinae is that it belongs to a rare class of stars called Luminous Blue Variables, or LBVs, objects whose temperature and mass approach the absolute maximum believed possible for a star. Eta Carinae appears to tip the scales at a mass 100 to 120 times larger than the sun while its surface broils at a temperature that ranges between about 22,000° and 50,000° Fahrenheit. Compare this to the surface temperature of the sun, which comes in around 10,000° Fahrenheit.

At its coolest, Eta Carinae also becomes most compact — though its size would still be large enough to swallow the orbit of Mercury if it replaced the sun. When the star's temperature rises, its radius swells and would reach the orbit of Mars or beyond. During the Great Eruption, the star probably expanded to a diameter of two billion miles, the size of Saturn's orbit.

Moreover, astronomers think that Eta Carinae has one of the densest solar winds known, blowing off about 0.003 solar mass per year, some six trillion trillion tons, or two Earth masses each day. At this rate the sun would evaporate in a little more than three centuries. But Eta hardly notices.

Such intensely large, hot objects must periodically shed additional large amounts of mass to remain stable.

What causes these larger eruptions remains a mystery, though astronomers suspect the incredibly high mass and temperature play key roles. The most popular hypothesis says that the star's luminosity is so great that it occasionally overpowers the gravity that holds the star together. The star becomes unstable; its outer layers pulse in and out as if unsure whether they wish to remain in place or gush into space. Eventually an eruption occurs and the outer layers are flung away.

With the loss of this shell of hot gas, the star cools and its surface temperature drops to a relatively low 13,000° Fahrenheit. At the same time, its electromagnetic output shifts from the high-energy ultraviolet to less energetic optical radiation, so though the star is now cooler, it radiates more brightly at wavelengths our eyes can see. Hence, while the star seems brighter, its overall output undergoes no intrinsic change.

After an eruption, these strange stars become stable for long periods, with their visible luminosity generally holding steady (though small, irregular fluctuations are not unusual). Whether the huge outbursts happen more than once is simply not known. If so, they are separated by thousands of years.

It is also far from clear whether the war between gravity pulling inward and the pressure of radiation pushing outward is the sole cause of these giant eruptions. Some scientists think that turbulence and convection on the star's surface either contributes to or causes the outbursts. Others believe that no current theory can be correct because none seems to explain adequately what instigates the eruptions as well as what makes them stop.

Grand and powerful, luminous blue variables such as Eta Carinae are among the rarest types of stars known. Fewer than three dozen have been identified, with five belonging to our Galaxy and the rest scattered among eight nearby galaxies in the Local Group. A good example is the first LBV discovered, P Cygni, which was unknown until it brightened to 3rd magnitude several times during the 17th century. It then stabilized at around 5th magnitude, where it remains today.

The significance of luminous blue variables is that they are thought to be a short-term transitional stage in the life of stars, spanning a mere 25,000 years or so. "Most stars above 40 to 50 solar masses will eventually go through an LBV instability phase," explains Humphreys. As the star sheds mass it slowly evolves from a blue supergiant to a Wolf-Rayet star, thought to be one of the last stages that stars reach before they die. Such stars have lost more than half to two-thirds of their original mass, have exhausted their hydrogen fuel, and now burn other, more complex atoms in their nuclear furnaces. Their next and final act, astronomers believe, is to explode as supernovae.

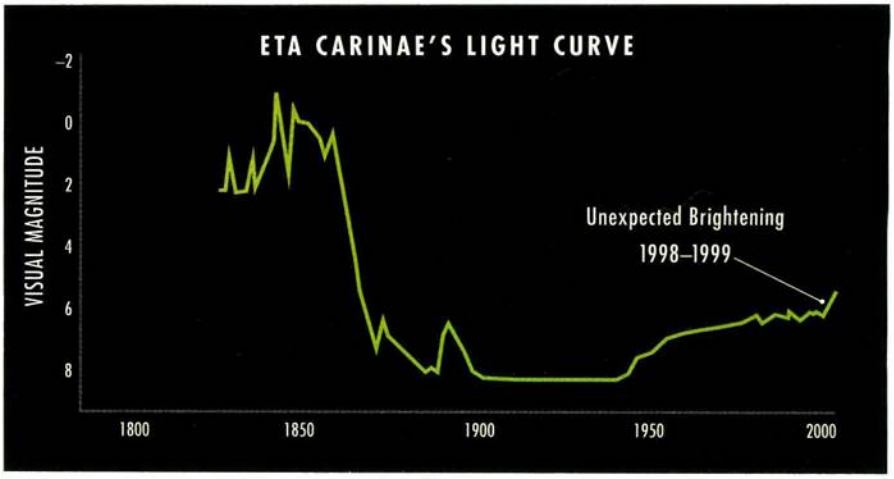
MORE MYSTERIES

Ironically, Eta Carinae's recent behavior has punched a few holes in the theories that try to explain luminous blue variables. From 1993 to 1998, the star's light output first dipped and then rose about half a magnitude, an event attributed at the time to Eta Carinae's continuing irregular fluctuations. The star, however, then began to brighten precipitously, rising one full magnitude in less than a year. As of June 1999, the star and the surrounding Homunculus glistened at about 5th magnitude, the brightest it has been since the Great Eruption in 1843. "Without question, the central star has brightened since 1997 by roughly a factor of two," notes astrophysicist Jon Morse of the University of Colorado, whose Hubble images in June 1999 confirmed this brightening. And if the brightening trend continues, Morse adds that "in two years we will not be able to take an image with Hubble without saturating the camera. [Eta Carinae] will be too bright."

While astronomers had expected the star might return to higher magnitudes sometime next century, no one had anticipated it happening so abruptly. Kris Davidson points out that "if you had asked us we would have told you it probably *wasn't* going to happen."

The brightening is even more puzzling because it is occurring across all wavelengths. If the star were merely ejecting an outer shell in response to radiation pressure, the brightening would happen only at visible wavelengths, with the star's outer layers cooling and its output shifting from the ultraviolet to the optical. An increase in brightness across the entire electromagnetic spectrum implies that Eta is growing intrinsically brighter, a possibility no theory predicted. Moreover, this brightening implies that the star's luminosity may soon overwhelm its gravity, once again causing the star to become unstable and erupt as it did in the last century. "And Eta Carinae can't brighten very much," notes Humphreys, "or else it will go boom."

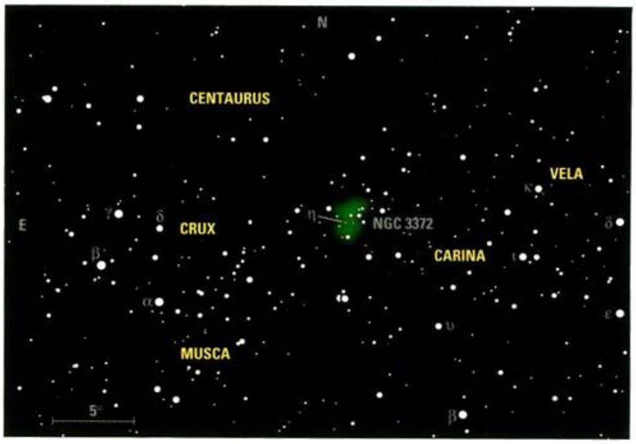
Adding to Eta Carinae's baffling story is the recent discovery by Augusto Damineli of the University of Sao Paulo in Brazil that the star's light fluctuations are not as irregular as once thought. Damineli's analysis of the star's spectrum reveals that every 5.5 years, Eta's ultraviolet and x-ray output undergoes a short-term change. In x-rays the flux increases steadily, then plunges, followed by a slow recovery. In the ultraviolet, several dark emission lines on the star's spectrum disappear. Damineli was able to trace this cycle back through the last 50 years. He also found that all the major outbursts of the previous century, in 1827, 1832, 1838, and 1843, seemed to line up with it. Finally, he successfully predicted an event in December 1997, at which time the star's x-ray output plummeted and the ultraviolet emission lines faded, as they had in previous cycles.



SPY THE MYSTERY STAR

Although it ranks among the biggest and brightest stars in the Milky Way Galaxy, Eta Carinae can be a challenge to see. Much of that difficulty arises from its southerly location: The star lies at a declination of –60°, which means it never even climbs above the horizon for observers at mid-northern latitudes. Observers throughout Europe, Canada, and most of the United States can't see it from home. However, those living or visiting the Southern Hemisphere or Tropics can easily find this intriguing object.

The best time to spot Eta (η) comes in February and March, when it lies highest in the sky from late evening to around midnight. First locate the Eta Carinae Nebula (NGC 3372), the brightest emission nebula in the sky. To the naked eye, it appears as the brightest spot along the Milky Way — clearly a large, nebulous glow. The star itself lies within the nebulosity, just north of the dark, V-shaped rift that slices through the nebula's center. — *Richard Talcott*



Astronomy: Elisabeth Rowan

Based on this cycle, a number of astronomers immediately proposed that Eta Carinae was actually a binary system with both stars hidden by the system's dense surrounding nebula — and that all previous eruptions might have been caused by the orbital interaction of two stars.

Unfortunately, no proposed binary system has yet explained Eta's behavior completely. Furthermore, a bewildering wave of new facts has swamped the theorists and left them scrambling to recover. "We've got so much data from so many wavelengths it's difficult to get one model to explain everything," notes Michael Corcoran of the Universities Space Research Association. For example, recent observations have discovered an additional 85-day cycle in x-ray emissions and a 200-day cycle in the ultraviolet, with hints of a 58-day cycle in the optical.

Although there's still much disagreement about the existence of all these cycles, most astronomers now attribute the star's powerful x-ray emission to the collision of two dense stellar winds, emanating either from the two stars of a binary system or from the fast and slow stellar winds of a single star. Astronomers suspect that the 5.5-year cycle occurs when the region where these winds collide is periodically eclipsed, either when one star moves behind the other or when the rotation of a single star moves the region out of our line of sight.

While most scientists today favor the binary hypothesis, others argue that a single star could still produce all the observed phenomena. Some have even considered the possibility that the system is comprised of a barely stable three-star system, whereby the Giant Eruption of the last century was caused when two of the three stars switched positions in an orbital dance of grand proportions.

In general, astronomers remain skeptical of all these theories — including some of their very advocates. No hypothesis is yet able to explain all the known facts, among them the star's inexplicable and stunning jump in brightness since 1998. As Davidson notes, "We really, truly do not understand what is happening, even at a fairly rudimentary level."

THE LIFE AND DEATH OF STARS

When you point a telescope at Eta Carinae, you are looking down the length of our Galaxy's Carina-Sagittarius spiral arm, which traces a corkscrew around the galactic center and is home to some of the Milky Way's most massive stars and most glorious nebulae. In such spiral arms stars are born. Eta Carinae lies embedded in a dense giant molecular cloud only a few million years old, about 425 light-years across, and containing the mass of 10,000 suns. Moreover, surrounding Eta Carinae's immediate environs are vast clouds of nitrogen and dust processed from hydrogen by the star's pile-driving nuclear engine.

"What's past is prologue," wrote Shakespeare. Astronomers now firmly believe that the formation of more commonplace stars is intrinsically linked to the feverish life and death of massive stars like Eta Carinae. These kingly objects not only process huge amounts of hydrogen fuel into more complex atoms such as carbon, oxygen, nitrogen, and iron, they also spray it out into the interstellar medium, accounting for a large percentage of the material found in the dense molecular clouds that surround them. Then, when such majestic stars go supernova, the explosion sweeps up this surrounding debris, forming a shock wave within which eventually flower the longer living but less massive ordinary stars — stars such as our sun.

Corcoran recently said that "The death of Eta Carinae is likely to be one of the most explosive events ever experienced in the Galaxy." When such massive stars go supernova, the energy released can be so powerful that it equals and possibly exceeds that of the rest of the Galaxy. Such explosions might also be the progenitors of gamma-ray bursts, events so energetic that even from a distance of several thousand light-years, the explosion could seriously damage life on Earth, possibly even wiping it out.

So while the explosion of lordly stars like Eta Carinae leads to the birth of new stars, it concurrently causes the destruction of life in nearby solar systems. Let us hope that our solar system is just far enough away so that we can enjoy the show without any tragic consequences. ■

Robert Zimmerman is a regular contributor to Astronomy. *His latest book,* A Chronological Encyclopedia of Discoveries in Space, *was published by Oryx Press in January 2000.*

RAISING LUNAR PROSPECTS

During its 19-month mission, Lunar Prospector exposed the moon's mysteries at a bargain-basement price.

by Robert Irion

YOU CAN STILL BUY A FEW THINGS FOR $63 MILLION: A minor league baseball team, an average Hollywood movie, or a long-shot presidential campaign. That sum also was enough to finance Lunar Prospector, NASA's first mission to the moon since the glory days of Apollo.

From its launch on January 6, 1998, to its plunge into a dark crater on July 31, 1999, Lunar Prospector was the spunkiest space probe in years. The tiny craft spotted the most convincing signs yet of vast stores of water ice at the moon's poles. It mapped the moon's lumpy gravitational field and traced the subtle fossils of an extinct magnetic field. The explorer also found evidence of a small iron core inside the moon, boosting a popular theory that the moon arose when a giant object slammed into the infant Earth.

Alan Binder was the driving force behind the successful Lunar Prospector mission.

Artist rendition of Lunar Prospector: NASA/Photo of Alan Binder: Lockheed Martin

"This mission was a raging success," says Prospector physicist Rick Elphic of Los Alamos National Laboratory in New Mexico. "The instruments and spacecraft were marvelous examples of how we can do things more cheaply."

Lunar Prospector was the brainchild of planetary scientist Alan Binder (see "The Man Behind the Mission," p. 50). Binder (pronounced "BINE-der") envisioned Prospector as a simple probe using proven technology. It would validate a fast and economical approach to solar system exploration. As a side benefit, Prospector would examine the moon's key scientific mysteries — and perhaps whet the appetites of lunar enthusiasts who might pay for future missions.

Binder thinks his oil-drum-sized vessel scored on all counts. "The science in particular has been phenomenal," he says. "It's been so much better than we thought. We've discovered things we didn't expect to see."

PROSPECTING FOR WATER

Notable results surfaced right away from a first-of-its-kind device on a planetary mission: a neutron spectrometer. Earth-orbiting satellites use neutron spectrometers to monitor illicit testing of nuclear weapons. At the moon, the application was less explosive. Cosmic rays from space bombard the lunar surface, generating sprays of neutrons and other particles. Some of the neutrons rattle in the moon's upper soil layers, losing energy as they interact with atoms and molecules before flying into space. Different substances in the soil leave "fingerprints" in the neutrons' energies. Hydrogen depletes more medium-energy neutrons than other elements do.

Prospector saw a marked deficit of medium-energy neutrons each time it flew over the moon's north and south poles. Clearly, lots of hydrogen lurks within the soil there. That was tantalizing, because hydrogen and oxygen combine to make water.

Researchers had long speculated that water ice could exist within cold nooks on the moon's surface where the sun never shines. Steep crater walls near the lunar poles could shade the soil for billions of years. Temperatures in these black patches could hover at –315° F (–193° C). That's cold enough to preserve any water molecules that might wander there from the impacts of comets and water-rich meteorites. Prospector's neutron data implied that these deposits of ancient ice were extensive indeed: up to two billion tons, mixed into the top several feet of soil. News reports touted the ice as a boon for future lunar colonists.

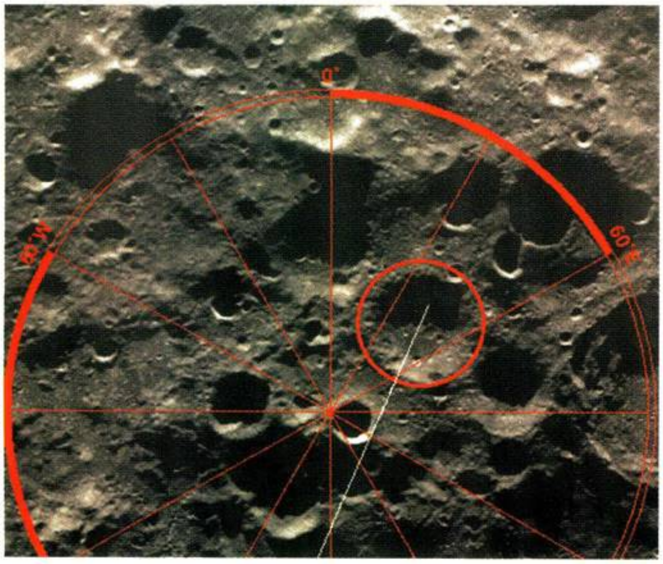
But water ice is not the only way to explain the neutron data. The sun blasts the moon's surface with the solar wind — torrents of hydrogen and other particles. Some of this hydrogen builds up in the soil. "The arguments to discriminate between water ice and solar wind-implanted hydrogen are very weak," says neutron spectrometer team leader Bill Feldman of Los Alamos. "Even so, we think the most likely interpretation is water ice."

Feldman cites three reasons why. Hydrogen is 30 times more abundant at the cold poles than elsewhere on the surface. Prospector's peak detections of hydrogen also match areas of permanent shadow seen by Clementine, a Department of Defense spacecraft that orbited the moon in 1994. Furthermore, astronomers estimate that watery manna from the solar system descends on the moon at a high enough rate to maintain icy deposits in the coldest spots.

But short of drilling into the suspected deposits, it will be hard to prove this scenario. Aerospace engineer David Goldstein of the University of Texas at Austin thought of one way: Why not smash the 354-pound (156 kg) probe into a dark crater when the mission was about to run out of fuel and money? The resulting plume of debris might rise 300 miles (500 kilometers) above the moon's surface and harbor signs of water. Binder and NASA liked the idea.

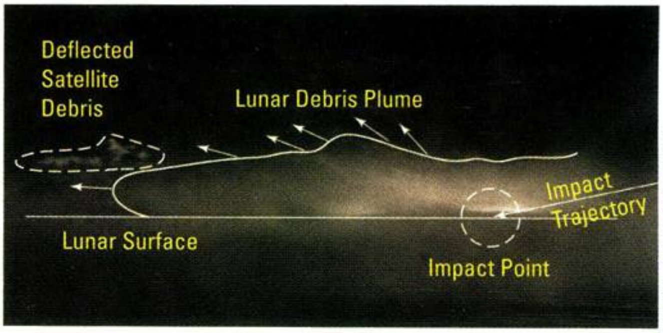
Last July 31, Prospector accepted Binder's final commands and dove kamikaze-style into a crater near the moon's south pole at 3,800 miles (6,100 km) per hour. The Hubble Space Telescope, the Keck Telescope in Hawaii, the Submillimeter Wave Astronomy Satellite (SWAS), and other major telescopes watched for the plume. If water vapor had wafted above Prospector's grave, SWAS should have detected it. The other telescopes looked for hydroxyl (OH), which arises when sunlight breaks apart water molecules.

Unfortunately, no signs of water or hydroxyl showed up. "It's not a negative result — it's an inconclusive result," says astronomer Ed Barker of UT-Austin's McDonald Observatory. The spacecraft might have struck the crater wall, hit a dry spot, or simply created a smaller cloud of debris than expected. Even before the impact, scientists estimated the chances of a water detection to be less than 10 percent.



The University of Texas at Austin

Right: Lunar Prospector (the blue cylinder on top) was one of the smallest interplanetary spacecraft ever launched. Left: Scientists plotted the desired trajectory of Prospector's final mission. They aimed it toward a south pole crater that is permanently shaded from sunlight, allowing water ice to remain frozen underground for billions of years. Below: If everything had happened just right, the impact would have kicked up a cloud of debris that included detectable amounts of water ice.



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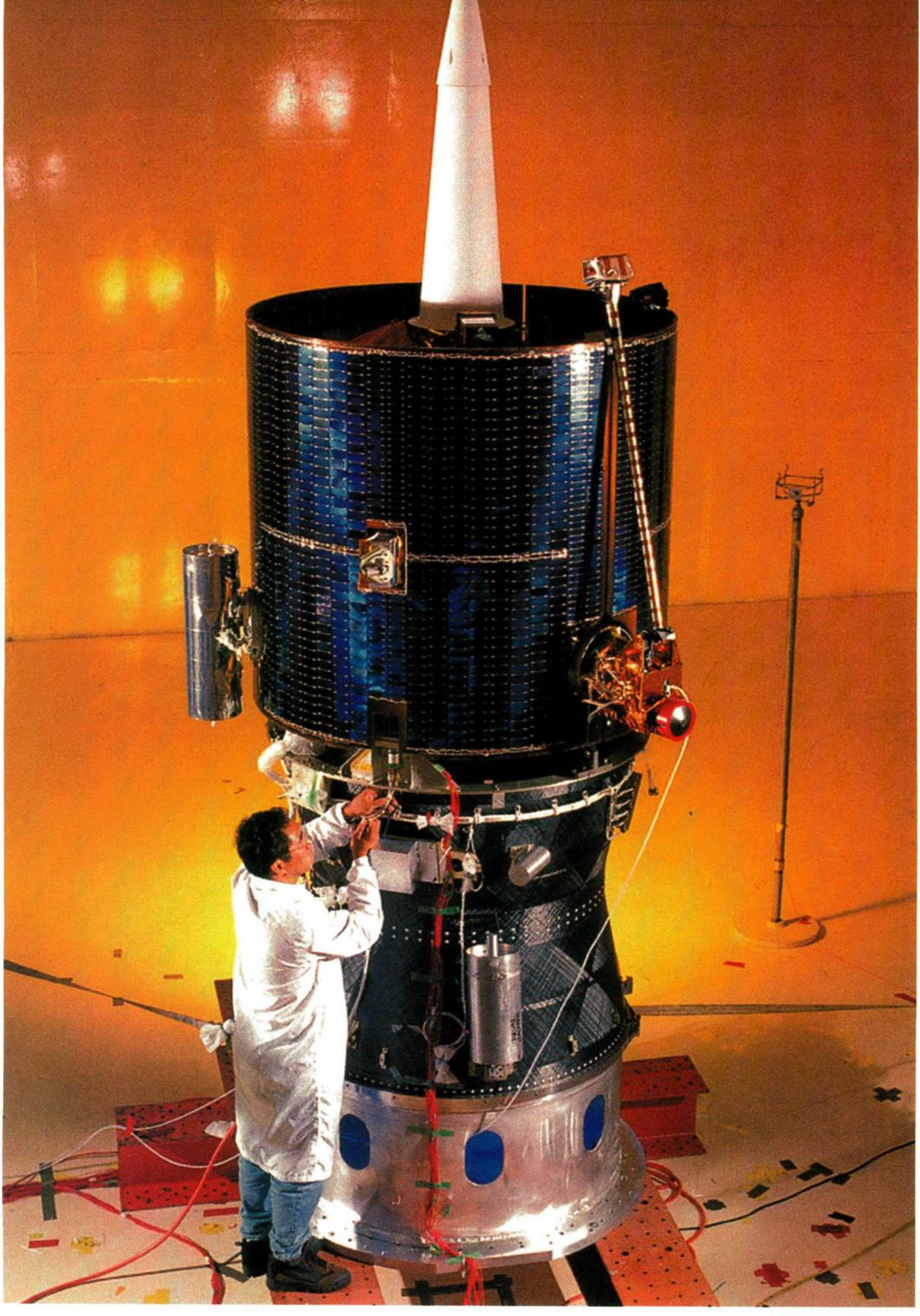
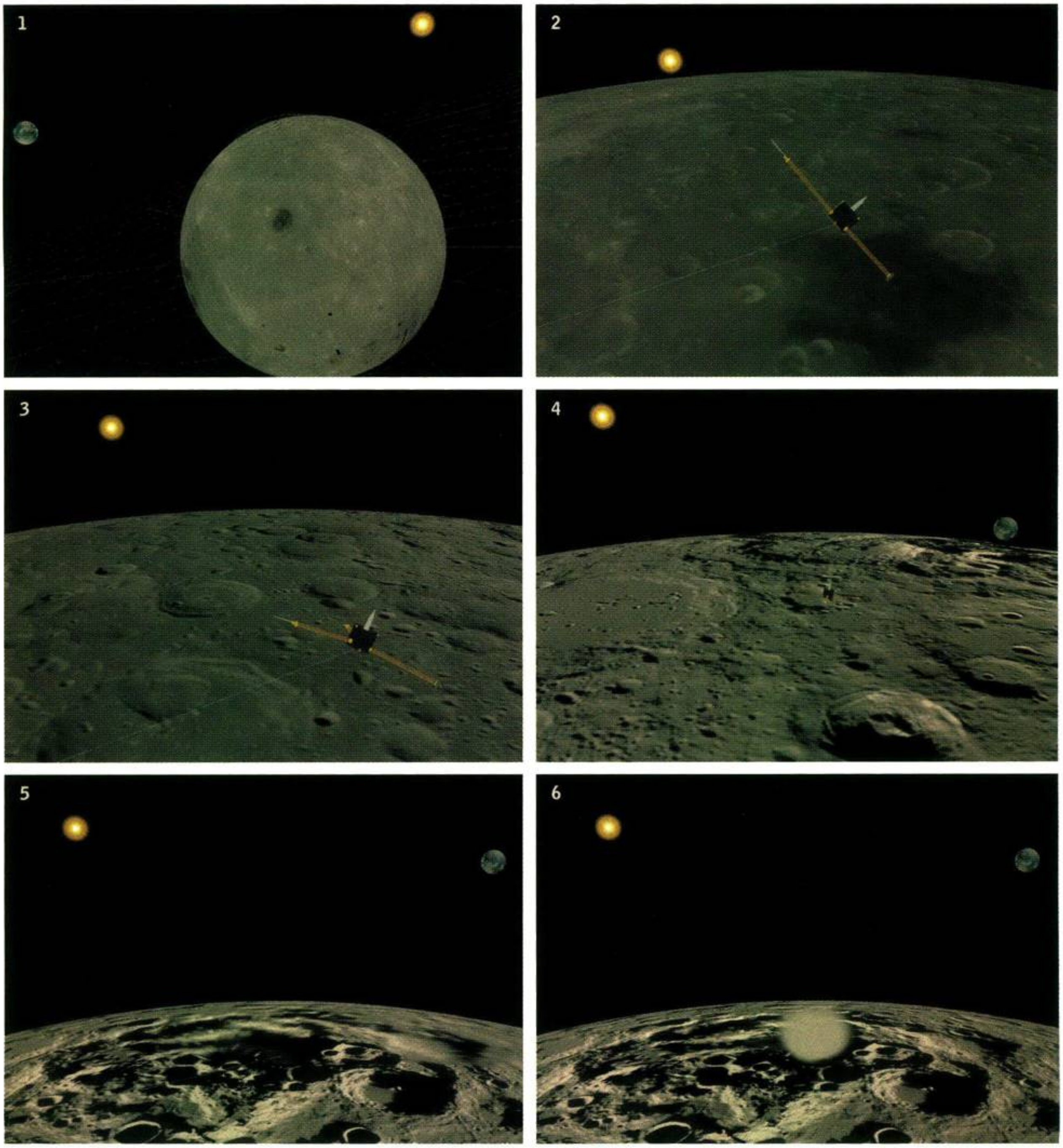


NASA

THE END OF PROSPECTOR



Analytical Graphics, Inc.

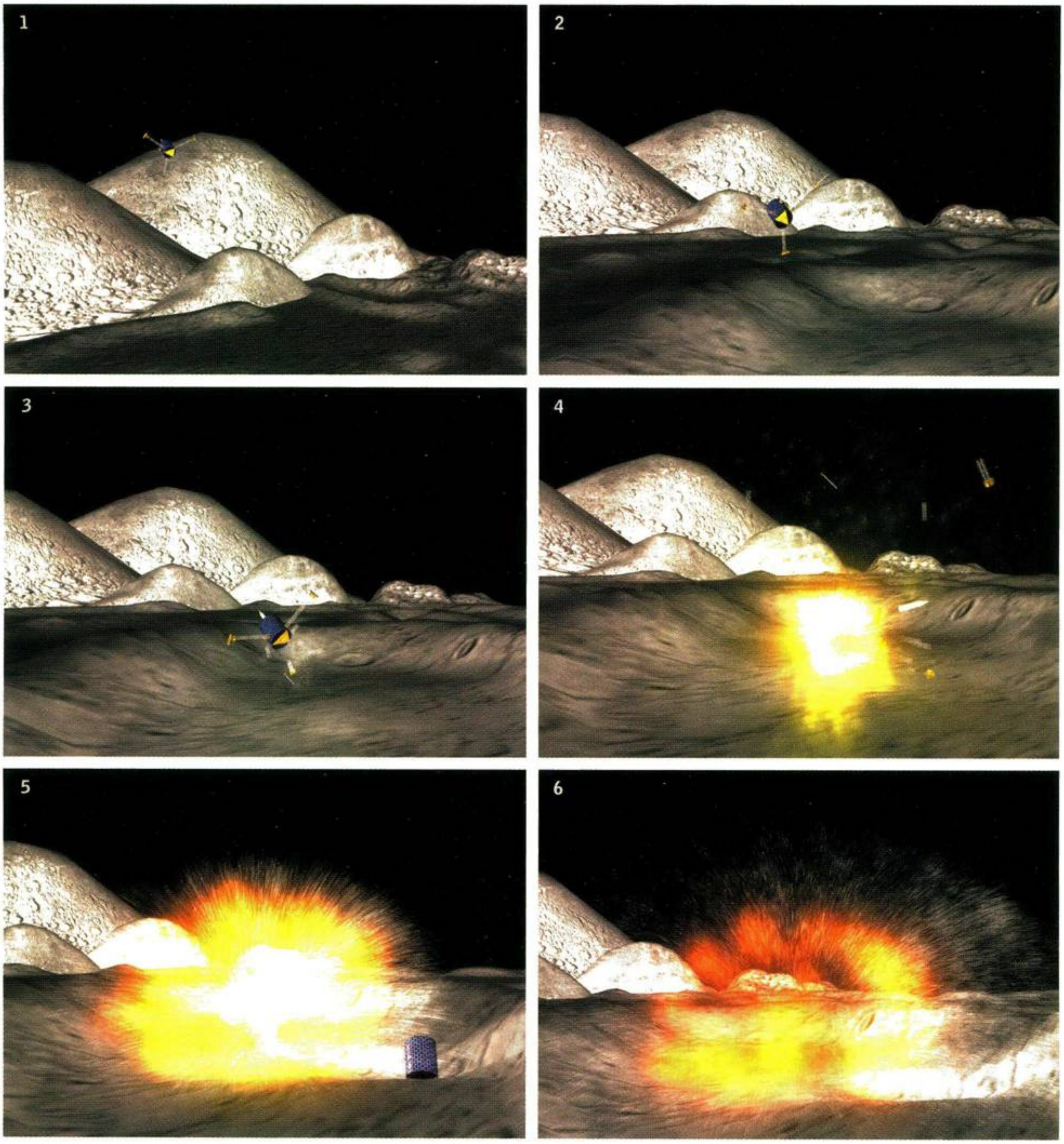
On July 31, ground controllers commanded Lunar Prospector to fire its engine and decelerate, causing the oil-drum-size spacecraft to crash into a lunar south pole crater at 3,800 miles per hour.

PROBING INTERNAL STRUCTURE

Beyond the water test, Lunar Prospector's data will help scientists piece together the moon's history. For instance, information from the spacecraft helped astronomers create a detailed lunar gravity atlas. Asteroid impacts and surges of molten rock from the moon's interior billions of years ago created density variations near the surface. These variations affected the gravitational pull that Lunar Prospector felt. This is akin to the difference between riding a bicycle over a flat road or a series of hills and valleys. The distance by air may be the same, but cycling the hilly road takes more work. Charting dense regions within the moon will show researchers how molten rock flowed and cooled within the first billion years of lunar history. It also will tell the planners of future lunar missions how to calculate their flight paths and fuel use.

Certain elements also hold the key to decoding events in the moon's early history. One of the most interesting is thorium, a radioactive element that spits out gamma rays

A FIERY FINALE



Walt Feimer/AlliedSignal, MaxQ Digital Group

when it decays. A gamma-ray detector on Prospector snared these fleeting bits of energy. Thorium is associated with a group of elements collectively known as KREEP, an acronym for potassium (chemical symbol K), rare-earth elements (REE), and phosphorus (P). These are "incompatible elements," because they did not fit into the mineral structures of heavy compounds that sank into the moon after it formed.

A KREEP-rich layer of rock was the last part of the moon to solidify. It formed a layer between the moon's mantle and crust. Large asteroid impacts should have punctured that layer and tossed KREEP-rich rocks hither and yon across the lunar surface. But Prospector found such debris near only one big impact scar: the Imbrium basin on the nearside. An even deeper impact, the South Pole-Aitken basin, dredged up comparatively little KREEP. This means the moon's internal structure may be lopsided, but no one can say why.

Scientists hoped the kamikaze crash would kick up a cloud of water vapor. But careful observations revealed not a trace of water.

Prospector surveyed many other key elements, including iron, titanium, and uranium, that will shed light on the moon's history.

THE MAN BEHIND THE MISSION

It takes teamwork to explore the solar system. Hundreds of engineers, programmers, navigators, and scientists contribute to billion-dollar missions such as Galileo and Cassini. On the other hand, a gathering of the Lunar Prospector team might fill a backyard. The proud father at such a reunion would be Alan Binder.

Few planetary mission directors could be as generous, refreshingly forthright, and fun to visit. As he displayed his model rockets and self-made telescopes at his former home in Gilroy, California, Binder admitted that Lunar Prospector was a surrogate for the child he never had. "God, I love that spacecraft!" he said, viewing a picture of Prospector. "Isn't that beautiful? It's my little baby." This devotion is one of the reasons Prospector thrived.

Now age 60 and as energetic as ever, Binder is one of lunar science's fiercest advocates. Thick scrapbooks document his childhood fascination with the moon and space. They include a collection of *Collier's* magazines from the 1950s, with lushly illustrated articles about the coming era of space travel.

The Apollo missions thrilled Binder as he completed his Ph.D. in geology and planetary science. When NASA abandoned the moon after 1972, he was crushed. "Apollo was the high point of this century, and we threw it all away," he says. "I find that a great historical tragedy."

For a time, Binder transferred his passion to Mars. He was a principal investigator on the 1976 Viking Lander missions. But the moon never left Binder's thoughts. He moved to Germany for 10 years to teach and conduct lunar research. While there, he planned a series of lunar orbiters, landers, and sample-return missions called Selene (the Greek goddess of the moon). The Apollo astronauts merely scratched the moon's surface, Binder says. "They spent a sum total of three working days there and collected samples from six small sites, out of a total surface area as big as North and South America combined. We have barely begun to understand lunar history."

When Binder returned to the United States in 1989, he set up a nonprofit corporation in Houston: Lunar Exploration, Inc. He created a blueprint for the first *Selene mission, Lunar* Prospector, and pursued private funding. Although some pledges materialized (including a $4 million advertising agreement with Pepsi), they weren't enough to get the project off the ground.

In the early 1990s, NASA, under the directive of new administrator Dan Goldin, announced a competition for its first "Discovery" set of "faster, better, cheaper" missions. Binder realized that NASA insiders no longer regarded the moon as a "sexy" destination. But he knew he could deliver an inexpensive probe to address key questions about the moon's history and resources, including water ice. He felt Lunar Prospector would win, as long as an independent review panel — rather than NASA itself — appraised its merits. That indeed occurred, and Prospector ranked first of 28 proposals.

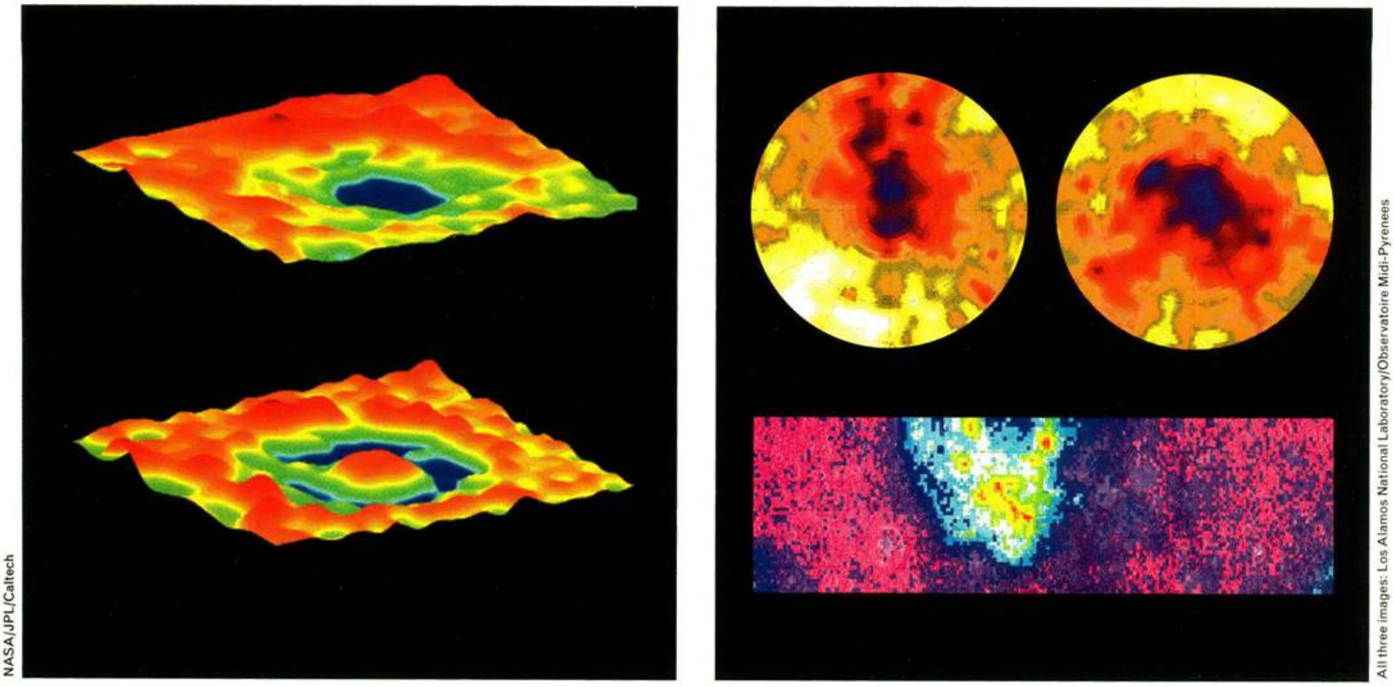
Thus began a curious marriage that one could politely describe as strained. Binder is an unapologetic NASA gadfly. He calls the agency's bureaucracy "totally inefficient." He also loathes the "technologically incompetent management" of the government-funded space industry — including Lockheed Martin, where he worked for years. To complete Prospector on time and on budget, Binder believed, he had to strip away the usual stifling layers of federal and industry oversight. To his surprise, NASA gave him free rein to do so.

Binder recruited a trusted cadre of engineers from Lockheed to build the spacecraft and a small team of experienced scientists to design the instruments. Their mantra was KISS: "Keep it simple, stupid." From start to launch, the process took about two years.

Prospector's perfect record vindicates his "renegade" approach, Binder says. He is dismayed — but not surprised — that subsequent missions in the Discovery program have grown far more complex, expensive, and laden with administrative wrangling.

Once again free from NASA, Binder recently revived his company (now called the Lunar Research Institute) in Tucson, Arizona, where he lives with his wife, Rebecca. His dream is to continue Selene with funding from private investors. "My ultimate goal is to set up a commercial lunar base," he says. "I believe the moon is the key to getting humanity off Earth. It will be the beginning of the first extraterrestrial culture."

Binder felt betrayed when the last steps on the moon 27 years ago led nowhere. But if he cannot launch another robotic child to the moon, he will not feel a similar letdown. "Lunar Prospector was the crowning achievement of my career," he says. "If other missions don't work, I could happily retire, build my telescopes, and enjoy the beauty of the universe we live in." — *R.I.*



NASA/JPL/Caltech

All three images: Los Alamos National Laboratory/Observatoire Midi-Pyrenees

Gravity maps from Lunar Prospector indicated mass concentrations under the Orientale Basin (far left). The spacecraft's neutron spectrometer pinpointed the possible location of water ice (dark blue) near both lunar poles (top). The gamma-ray detector showed concentrations (bright colors) of thorium (above).

AT THE MOON'S HEART

Two instruments, a magnetometer and an electron reflectometer, found faint imprints of ancient magnetic forces on the moon. Unlike Earth, the moon has no global magnetic field. But some patches of lunar rock retain enough magnetic strength to prevent charged particles in the solar wind from reaching the surface. By and large, these patches are on the opposite side of the moon from the enormous impact basins we see as the dark "seas."

According to physicist Robert Lin of the University of California at Berkeley, a major impact throws a massive cloud of dust and rock around the moon. As the cloud expands, it sweeps some of the magnetic field along with it. Then, on the side of the moon diametrically opposite the impact, the debris converges violently. The compressed magnetic field becomes very intense at the site of these convergences. A process called "shock magnetization" may preserve a record of the intense field within the mineral grains of the colliding rocks.

"If we can confirm these observations, it's strong evidence that the moon once had a molten core," Lin says. The spinning motions of this core may have created a magnetic field as strong as Earth's is today. But the core probably cooled and partially solidified about 3.6 billion years ago, so the field died out.

Two other studies from Lunar Prospector data also suggest that the moon has a small iron-rich core. Jet Propulsion Laboratory planetary scientist Alex Konopliv and his colleagues used the gravity data to refine their estimates of how the moon's internal mass is distributed. The results point to a core between 275 and 560 miles (440 to 900 km) across. A team led by planetary scientist Lon Hood of the University of Arizona used Prospector to probe for magnetic perturbations as the moon entered a quiet part of Earth's magnetic bubble. They saw little flutters, perhaps produced by a small core that deflected Earth's magnetic field slightly. Hood's size estimate for the core matches well with Konopliv's: 310 to 535 miles (500 to 860 km) across.

Such a small core would contain only about two percent of the moon's mass. Earth's core, in contrast, holds 30 percent of our planet's mass. That's good news for the leading model of the moon's origin, called the "giant-impact hypothesis." First proposed in 1975, the impact scenario maintains that a Mars-size object collided with the still-forming Earth some 4.5 billion years ago (see "Deconstructing the Moon," September 1998). The cores of both Earth and the impactor already were rich with dense iron, which settles inward like pulp falling to the bottom of a glass of lemonade.

The violent collision would have thrown molten rock into orbit around Earth. Within a few years, according to computer simulations, this rock coalesced into the infant moon. The simulations predict that such a moon would contain mostly lighter rock from the outer layers of the impacting object, with just a smattering of iron to form a small core. That's what Prospector appears to see.

Such chaos is hard to imagine today when we see the moon's calm face overhead. "The moon is close to home, but it's still a foreign land, an alien province," says Elphic. "It seems so simple, yet Lunar Prospector has shown that its history is remarkably complex." A

To view animated movies of Lunar Prospector crashing into the moon, visit *Astronomy* magazine's website at http://www.astronomy.com.

Contributing editor Robert Irion is a freelance writer in Santa Cruz, California. He is coauthor of One Universe: At Home in the Cosmos *(Joseph Henry Press), a coffee-table book on physics and astronomy due in bookstores by March.*

Destination Moon

by Carolyn C. Porco

Renowned geologist Gene Shoemaker aspired to visit the moon. He never made it, but his ashes did.

I don't remember when I first met Gene Shoemaker, but chances are I heard him before I saw him. He was a warm, jovial, and boisterous man, with a hearty, body-quaking laugh that bounded its happy way across a room, a laugh that seemingly could defy physical law and pierce vacuum. And because he was always laughing, one's encounter with the man usually began acoustically. Mine probably did too. Neither one of us, of course, could possibly have foreseen that the crossing of our lifelines on that day would lead, some 25 years later, to Gene's history-making interment on the moon. The cause and effect of human affairs is often invisible to its players.

In 1976 I was a graduate student in the Division of Geological and Planetary Sciences at the California Institute of Technology in Pasadena. I had come to the study of geology reluctantly. I was, after all, from the Bronx. I hadn't seen a cow until I was 16, and I certainly knew nothing about rocks. So, it must have been the thrill of adventure that inspired me to sign up for a geology field trip by caravan across the deserts between Pasadena and northern Arizona, and then by raft down the Colorado River through the lower part of the Grand Canyon. Gene Shoemaker was the professor of geology who would lead the expedition.

I didn't know then that Gene was a legend, that he had been involved in the space program from its earliest days, that he was responsible for persuading the infant NASA to conduct scientific investigations of the lunar surface during the Apollo missions, that he wanted to be the first scientist-astronaut to go to the moon and study its geology firsthand, that he helped train the astronauts to recognize and retrieve rocks of geologic interest, that he was responsible for establishing the science of photogeology (the study of a planetary surface from images), that he was directly responsible for our understanding of the chronology of early solar system history. I would not find these things out for a few more years. I just knew I wanted to run the rapids of the Grand Canyon.

Gene, I came to learn, was part cowboy raconteur, part Buddhist monk — a charismatic, denim-clad storyteller so completely one with his world, his work, and his life that a typical stop-look-see field expedition in the rudiments of southwestern U.S. geology became a magic carpet ride.

By the time it reaches northern Arizona from its source in the western Rockies, the mighty Colorado River has sliced its way through 600 million years of history and through the colorful rock layers that form the walls of the Grand Canyon. This was Shoemaker country, a region the man knew intimately: its slopes and elevations, the dip of its beds, the sequence of slow changes that raised the land and laid the river, ultimately in the channel it cuts today. In Gene's recounting, the plateau became a mythical land, transformed many times over by ancient upheavals and the ebb and flow of the ocean. And his passionate storytelling ensured that his rapt audience could see it all take place right before our eyes.

Never mind that Gene was a disorganized tour guide who routinely flirted with danger. We sometimes ended up pitching camp in the canyon after dark on impossible slopes. Our rafting excursion nearly ended in disaster when Gene, cursing as heartily as he laughed, couldn't start the outboard motor that was supposed to push all our tied-together rafts across Lake Mead. None of this really mattered. To walk on the roof of the Colorado plateau, to float through its many layers with Gene, was to comprehend, to respect, and to experience, with the mind and senses aflame, the deep antiquity of the place.

The man was in the habit of thinking deeply and reaching far. In 1960, he demonstrated something that jolted the complacency out of everyone who was paying attention: Earth had been struck by a celestial projectile, measuring 150 feet (45 meters) across and traveling faster than a speeding bullet. And Meteor Crater, a 550-foot-deep, 4,000-foot-wide bowl-shaped depression near Winslow, Arizona, was the scar to prove it. In a

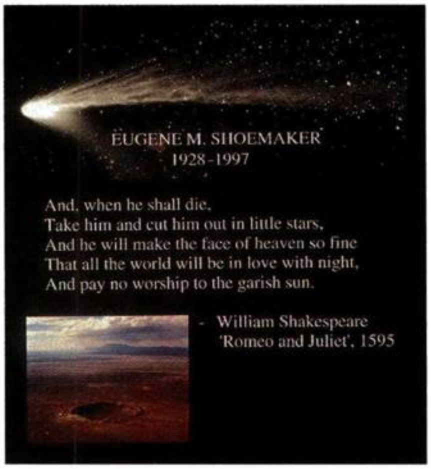
Gene Shoemaker, standing in Meteor Crater, became the first person whose remains ended up on another world: the moon.

Gene Shoemaker photo: Dieter Heinlein / Moon photo: Bill and Sally Fletcher

single mental leap, Gene had made a connection between the heavens and Earth that no one before him had seen. Terrible destruction could rain down on our planet from above. And he was convinced that the craters on the moon, widely believed at the time to be the result of explosive volcanic eruptions, were the result of the same cosmic hailstorm.

By the time I enrolled for my second field trip with Gene to visit and examine Meteor Crater, I was aware of "The Story." Gene had desperately wanted to go to the moon himself as an Apollo astronaut to test out his ideas on the cosmic origin of craters, but Addison's disease had grounded him. The Apollo program, however, had proven him correct: The inner solar system was at one time an incredibly violent place.

Accompanying Gene Shoemaker's ashes to the moon was a small plaque that contained two photos and a passage from *Romeo and Juliet*.



EUGENE M. SHOEMAKER
1928-1997

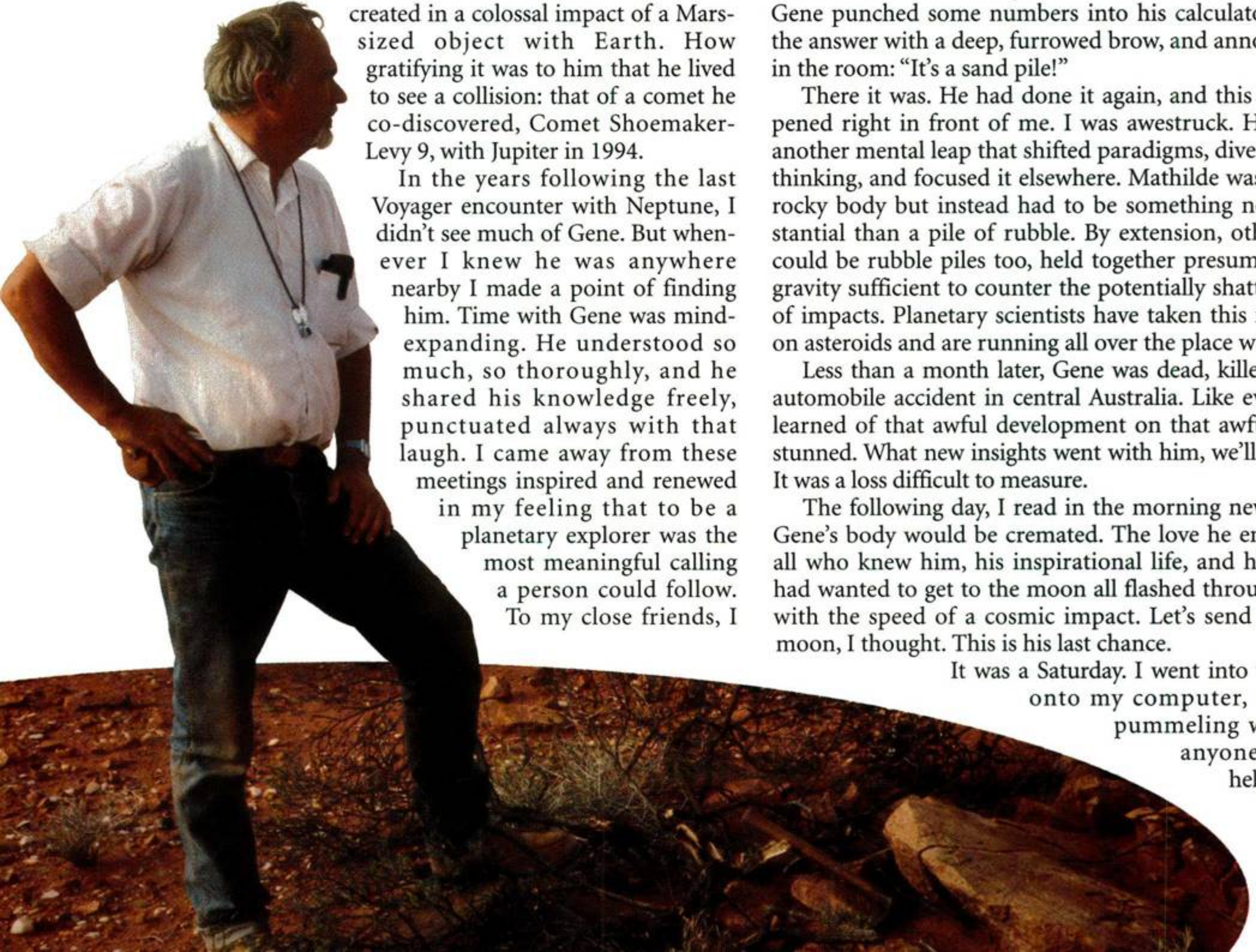
And, when he shall die,
Take him and cut him out in little stars,
And he will make the face of heaven so fine
That all the world will be in love with night,
And pay no worship to the garish sun.

- William Shakespeare
'Romeo and Juliet', 1595

In the 1980s, Gene and I met up again as members of the Voyager Imaging Team. The Voyager discoveries of a similar epoch of violence in the outer solar system, as recorded on the icy satellites of the giant planets, gave Gene much to think about. Employing his technique of determining the relative ages of the surfaces on a body by looking at the spatial density of craters, Gene broadsided everyone again by informing them that not only had these bodies suffered severe impacts, but that some of them had been broken to bits and reassembled, and in some cases, many times. Collisions were everywhere and could destroy worlds or even create them. Our own moon was created in a colossal impact of a Mars-sized object with Earth. How gratifying it was to him that he lived to see a collision: that of a comet he co-discovered, Comet Shoemaker-Levy 9, with Jupiter in 1994.

In the years following the last Voyager encounter with Neptune, I didn't see much of Gene. But whenever I knew he was anywhere nearby I made a point of finding him. Time with Gene was mind-expanding. He understood so much, so thoroughly, and he shared his knowledge freely, punctuated always with that laugh. I came away from these meetings inspired and renewed in my feeling that to be a planetary explorer was the most meaningful calling a person could follow. To my close friends, I would call an encounter with Gene "My Shoemaker Fix." I had become a Gene junkie.

His wife Carolyn later told me that the man was always thinking, punching his calculator, pursuing new ideas, rejecting bad ones. He was brilliant; he was renowned. He should have been richly rewarded and well-supported in his research. Yet, even he wasn't free of the trials and burdens of a modern-day scientist. To do any scientific investigations, he too had to write proposals and gain financial support of some kind. And he wasn't always successful. He was as frustrated as the rest of us.



The last time I saw Gene was at the Applied Physics Laboratory in Laurel, Maryland, during the NEAR spacecraft's June 1997 encounter with the asteroid Mathilde. Gene and his wife were, like myself, special guests of the NEAR science team. We could sit back and enjoy the views. Mathilde would be only the third asteroid visited by a spacecraft, and it was a different class from the other two. The images showed an asteroid that was mostly crater: huge chunks taken out of it by the ubiquitous process of impacts. Tracking the spacecraft as it passed Mathilde allowed a determination of the asteroid's mass. The density was low, possibly as low as water ice. But the asteroid certainly wasn't made of water. What was it? Gene punched some numbers into his calculator, looked at the answer with a deep, furrowed brow, and announced to all in the room: "It's a sand pile!"

There it was. He had done it again, and this time it happened right in front of me. I was awestruck. He had made another mental leap that shifted paradigms, diverted people's thinking, and focused it elsewhere. Mathilde was not a solid, rocky body but instead had to be something no more substantial than a pile of rubble. By extension, other asteroids could be rubble piles too, held together presumably by self-gravity sufficient to counter the potentially shattering effects of impacts. Planetary scientists have taken this new outlook on asteroids and are running all over the place with it.

Less than a month later, Gene was dead, killed in a tragic automobile accident in central Australia. Like everyone who learned of that awful development on that awful day, I was stunned. What new insights went with him, we'll never know. It was a loss difficult to measure.

The following day, I read in the morning newspaper that Gene's body would be cremated. The love he engendered in all who knew him, his inspirational life, and how badly he had wanted to get to the moon all flashed through my mind with the speed of a cosmic impact. Let's send Gene to the moon, I thought. This is his last chance.

It was a Saturday. I went into work, logged onto my computer, and started pummeling with e-mails anyone who could help in furthering this idea. What is

Gene Shoemaker in Australia photo: Kunihiko Niishizumi / Plaque design: Carolyn C.Porco

Richard L. Naeye

One of Gene Shoemaker's favorite places: the Grand Canyon in Arizona.

the next lunar mission? When will it be launched? Would it be technically feasible to include a small, lightweight capsule with perhaps an epigraph? How do I get in touch with Carolyn Shoemaker (who was injured herself in the accident and recuperating somewhere in a hospital in the middle of Australia) to find out if she would approve the idea?

Within 30 hours I had my answers: It's amazing how many people in the space business can be found working on the weekend. Lunar Prospector was the next mission going to the moon. But it was in final systems testing, to be shipped to Cape Canaveral from Moffett Field in California within two months. Even though it was late in the game, mission manager Scott Hubbard was warm to the idea (so long as the mass could be kept to a minimum), and Carolyn Shoemaker had sent back the message that the Shoemaker family would be forever grateful if I could actually pull it off.

And within nine days, I had the go-ahead from the NASA official who could make it happen. Associate Administrator for Space Science Wesley Huntress had responded, "I like that idea, Carolyn. I like the poetry of it."

It was a bit of a scramble as there wasn't much time. I wanted to include something to commemorate Gene's scientific legacy. It seemed appropriate to choose his favorite photo of Meteor Crater and a photo of the last comet that he and his wife saw together, Comet Hale-Bopp. And somehow, I extracted from the dusty realm of dim memory a passage I had read from *Romeo and Juliet* long ago that seemed perfect for the occasion.

In one crazy weekend in late August 1997, the idea turned into reality. On Friday I drove from Tucson to Phoenix, where I had arranged to have my design laser-engraved onto a small piece of brass foil. The following day I drove north to Flagstaff. That afternoon, in an intimate ceremony in the back of Gene's house, in view of his beloved San Francisco Peaks, members of the Shoemaker family and I collected Gene's ashes into a small capsule. The next day, I drove to Phoenix for a flight to Ames Research Center in California, where the following day, a Monday, I delivered the whole package to Scott Hubbard. It was then out of my hands.

On January 6, 1998, Lunar Prospector was finally sent on its way to the moon. Eighteen months later, on July 31, 1999, it crashed on command into the lunar south polar region, carrying Gene's ashes down to the surface. The fulfillment of one man's dreams, and the final episode of his inspirational life, met on impact.

In the last two years, my Shoemaker Tribute website (condor.lpl.arizona.edu/~carolyn/tribute.html) has received thousands of hits from people all over the globe. People I don't even know have expressed gratitude for honoring this man's wish to get to the moon and describe being moved to the point of tears after hearing the story of Gene Shoemaker.

It is a story that reverberates many places in the heart. It is one man's story for sure: of his dream, his disappointment, his life lived to the fullest, his legacy, and his final journey home. But it is our story, too. Thirty years ago, we humans arrived at the moon in life, and now one of us has arrived there in death. We have put our mark on the heavens and they have become our own. And now they beckon like never before.

What is it that makes one person see things that others don't, think thoughts that others wouldn't dare, and go places that others will only imagine? It's hard to say. But Gene was one of those people. And if there was ever a person who deserved to be given this special place in history, of being the first human to be sent to rest on another celestial body, it was he. To those of us who knew and loved him, that silver orb in the night sky will never be the same. May his laughing spirit walk its barren, windless reaches in peace, forever. ▣

Carolyn C. Porco is a planetary scientist at the University of Arizona and the Imaging Team Leader for the Cassini mission to Saturn.

As Time Goes By

Astronomy buffs from cosmologists to observers know that space and time are inextricably linked.

by Bob Berman

Fascination with astronomy is automatically a preoccupation with time, for space and time are inexorably entwined. Yet, oddly, our love affair with the cosmos often overlooks the time factor.

Of course, every backyard astronomer knows that a favorite galaxy returns annually at a particular month and hour. And variable-star observers carefully note the time of maximum or minimum light. Also, occultation studies require notation of the eclipse's exact moment. Even a simple telescope won't track sky objects without a clock drive that turns every 23 hours, 56 minutes, and 4.1 seconds – Earth's spin rate.

Serious Mars watchers know that its rotation period of 24 hours, 37 minutes, 23 seconds makes its features appear about a half hour later each night. And the marching-band cadence of the jovian moons Io, Europa, and Ganymede (which orbit Jupiter in an exact 1–2–4 ratio) have intrigued observers for four centuries.

A full list of such activities would fill volumes; astronomers' time-critical projects are obvious and endless. An accurate source for the right time is all you need to get started.

Photo illustration by Steve Puetzer

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But the subject of time runs much deeper; it crops up again when viewing anything and everything in the cosmos because of light's finite speed. Though in a vacuum electromagnetic radiation zips along at 186,282.4 miles per second (and increasingly slowly in denser media such as nebulae, water, or glass), the delay in light's arrival time caused by the distance it must travel repeatedly helps or plagues astronomers.

By happy coincidence, light requires a nanosecond (a billionth of a second) to move one foot of distance. This means we view the past by as many nanoseconds as we are feet away from the object under inspection. When watching a play from seats in the upper balcony 500 feet from the stage, what you observe arrives at your eyes 500-billionths (or half a microsecond) later than its actual physical occurrence. No one demands a refund.

TIME has come to our aid again by letting us view a scrapbook of the cosmos.

But now consider satellites transmitting time beeps. From a distance of 17,000 miles, the signals require nearly a tenth of a second to reach your location. If your receiving device has its own reference time and picks up signals-delayed-by-distance from three or more satellites, it can quickly decide how far you must be from each one, do a fast triangulation, and calculate your exact location. Presto: The marvelous GPS (Global Positioning System) navigation scheme.

Observations of the Galilean moons' orbits led to the discovery of the speed of light. In 1675, Danish astronomer Olaus Romer noticed that Jupiter's moons orbited faster than normal for half the year but ran "slow" the other half. He correctly deduced that Earth must be farther away from the giant planet and its moons during the slow time, causing each "frame" of the movie to be delayed in its arrival. Knowing our rough distance from Jupiter allowed an accurate (within 25 percent) determination of light speed.

So far, we've seen time as an ally in our study of the cosmos. And it comes to our aid again when peering into deep space. The fact that we see Saturn as it was an hour ago has as little significance as yesterday's soap opera episode. When viewing the stars Vega or Rigel, it doesn't make much difference that their light has been traveling for 25 to 800 years. True, if we ever receive a "hello" signal from a civilization on a planet orbiting one of those suns, we'd know that the greeting originated decades or centuries ago. The suspicious among us might wonder whether their present rulers have the same benign intentions as those who originally offered friendship. But these are political rather than astrophysical concerns.

Even knowing that we see the Andromeda Galaxy as it was more than two million years ago neither ruins nor makes our day: Galaxies barely evolve in so short a time. But when we examine galaxies billions of light-years away, the time lag suddenly becomes very important. Now as we gaze at objects as they appeared so long ago, we might see signs of a universe-wide evolution, if one exists. Specifically, we should immediately be able to tell whether the universe continuously replenishes itself (steady state) or popped into existence in the distant past. If the universe forever abides in more-or-less the same condition it displays today, then looking into the distance (i.e., the past) should reveal scenery that resembles what we find around here (meaning now).

But that's not what we see. In the distance we find numerous fragmented protogalaxies with younger stars, fewer spiral galaxies, and fewer giant elliptical galaxies — a very different scene from the inventory of our own neighborhood. The universe does evolve. The past is different from the present. The Big Bang, or some formative event, did happen. Time has come to our aid again by letting us view a scrapbook of the cosmos.

This is why cosmology considers time to be as critical as the objects and events unfolding in it. It all seems neat and tidy. We could close the story right here, were it not for the problems that lurk within every clock. For time, alas, has wrinkles — a dark side.

Things started to become seriously disconcerting with Einstein's strange but grudgingly logical ideas that were incorporated into both his special and general relativity theories of 1905 and 1915. In them, Einstein elaborated on and explained curiosities and paradoxes noted in the preceding decades by Michelson and Morley, Fitzgerald, and Lorentz. In a nutshell, a totally unexpected revelation emerged: Time is not a constant like light speed, gravity, or the mass of the electron. It flows at different rates. The presence of a gravitational field retards the passage of time, as does rapid motion. We're intuitively ignorant of this because we all attended a high school where everybody hung out in the same gravitational field, and we never, even in our wildest teenage years, drove our car faster than 1/8,000,000 the speed of light. Since one must go 87 percent of light for time to appear to slow by half its normal rate, we've never even come close to directly experiencing time's fickleness — a function of our still-sluggish ground vehicles rather than any personal wisdom.

Astronauts do better. Orbiting at 1/26,000 the speed of light, they can actually gauge the amount by which their time runs slow, using sensitive clocks — which brings up a seldom discussed puzzle. Though they move faster, astronauts have also traveled away from Earth's surface into a weaker gravity, which has the opposite effect of speeding their passage of time. Guess which wins out: Do shuttle astronauts' watches run slower or faster than they did back home? Answer: Their speed-factor prevails. They age less quickly than people on the ground. Turns out, they'd have to be ten times higher up, 2,000 miles above Earth's surface, before the weaker gravity exactly balanced their now-slower orbital speed to let them age at the same rate as those back home. Even farther away, timepieces on the moon tick faster than those at mission control in Houston. (But nobody compensated Apollo crews with early retirement benefits.)

These time distortions aren't subtle, nor are they merely of academic interest. Those GPS satellites simply wouldn't work if continual compensations weren't added for various time-warping effects. Since receiving precise time signals from each satellite lies at the heart of the GPS system, anything that throws off the instruments' or receivers' time passage will blow the whole thing.

Wrinkle one: Satellites travel at thousands of miles per hour, slowing their clocks. Wrinkle two: They're away from Earth in a reduced gravitational field, which accelerates their time. Three: Each GPS user on the surface is located at various distances from Earth's center (at Denver's high altitude, say) producing a variety of time-passage rates. Four: The difference between Earth's rotation speed at separate ground-based locations produces inconsistencies in their agreement about the passage of time (the Sagnac effect). Five: Time runs slower for all earthly observers because of our planet's 1,040 mph spin at the equator. Six: Satellites' time passages continually mutate because their elliptical orbits make them speed up and slow down a la Kepler's second law. All told, six separate Einsteinian time distortions affect receivers' clocks; half of these also distort the satellites' clocks. They must all be accurately and continuously corrected. Any one distortion would ruin the system's accuracy.

Still think time warps are only a mind game, a mere theory? Amazingly, Einstein's time dilation has even caused death. When cosmic rays (highly energetic particles striking our atmosphere) collide with molecules in the upper layer of air, they break atoms apart like a cue ball smashing a stack of billiards. The resulting rain of subatomic particles includes some that can be lethal to humans if they strike the right bit of genetic material. These muons dash through our bodies constantly, causing some of the spontaneous natural cancers that have always plagued our species. The point is, muons (intermediate in mass between protons and electrons) exist for just a few microseconds before decaying into harmless byproducts, and a few microseconds is not long enough for them to make it all the way to the surface and into our cells. They should not be able to reach us. They should not cause us any trouble. But they do — existing this long only because their time has slowed due to their high speed. From the particle's perspective, time passes normally. To us, its life has been extended — and ours consequently shortened.

There are places in the cosmos where a million years pass while a single second simultaneously elapses here on Earth. Yet both feel a normal passage of time. Observers will experience such contradictory time passages or out-of-synch sequences of events depending on their locations and speeds, yet they'll always agree about those events if they consider them unfolding in spacetime. For this reason, Einstein constructed the matrix, with time now seen as a fourth dimension. Using spacetime, instead of viewing time and space independently, allows paradoxes to vanish. Logic can prevail once more.

Most of us have been slow to realize that time is changeable. But in truth, time's fickleness may extend beyond mere warping. The situation may be much worse than that.

TIME is not a constant like light speed, gravity, or the mass of the electron. It flows at different rates.

Throughout this century, physicists increasingly wondered whether time exists at all. Here they share a temporary brotherhood with philosophers and metaphysicians who have always looked at time suspiciously. After all, the past seems to be just a selective memory: Your recollections of an event are different from mine. Both memories are simply that — signals from brain cells, neurons firing in the present moment. If the past is an idea that can only occur in the here-and-now, and the future is also just a concept happening strictly in the present, is there really a past and future? Or just a continuum of present moments — including the mind's ability to link events with thought?

The simple fact that physical laws do not seem to need time in order to work supports this heresy. Newton's laws, relativity, and quantum mechanics all appear to be time-symmetrical. They work just as well backward as forward. And although theoretical issues in the sixties suggested that time might not be as readily reversible as previously thought, not a shred of actual evidence supported the idea that there really is a one-way flow of time.

The only place in the physical universe where you inarguably need a directionality of time is in thermodynamics' second law, commonly pictured as entropy. That process of going from order to disorder, like your desk drawers, happens in just one direction. Things do not naturally flow from randomness to structure without outside influence, only the other way around. If you toss a few ice cubes into a glass of club soda, you'll see how structure changes to sameness. In time, the temperature differences vanish, bubbles go flat, ice melts, and, barring evaporation, you're left forever with a glass of water. Try it the other way. Put out some water and see how long you must wait before nature spontaneously coughs up cubes of ice and carbonation.

So entropy is a one-way street. On Earth, increasingly complex life-forms and intricate human technology have appeared over time — seeming to contradict entropy — but it has happened only because Earth gets energy from the sun. Taking the Earth-sun system as a whole, there's been an overall increase of entropy (disorder) because the sun has lost mass and differential structure over the eons.

Most scientists see the entire universe as a closed system in which entropy rules. If so, then a directionality of time exists, and time must be real. (The "arrow" of time is sometimes defined as the direction toward increased entropy. This idea once led Stephen Hawking to claim that if the universe ever starts contracting, time will run backward. But later he changed his mind, as if to demonstrate the process.)

Finally, late in 1998, two teams of physicists, using the world's largest particle accelerators, found the first actual (if subtle) evidence of time-directionality. In matter-antimatter experiments, a variation in the way subatomic particles moved and a slight excess in the transformation of one to the other indicated an asymmetry of time. If it holds up, this breakthrough has vast implications, since time's absolute validity would be forever suspect without a demonstrable direction to its flow.

Even if verified, time's asymmetry remains mysterious. Why should time unfold one way more than another? Is it a manifestation of some deeper force? Perhaps time is merely one thread in a grander tapestry that includes other cosmological imbalances such as the universe's expansion and the predominance of matter over antimatter.

For now, the fourth dimension's true nature and how it fits into the larger jigsaw puzzle remains an open question, whose answer lies somewhere in . . . another time.

Bob Berman's most recent article for Astronomy *titled "Less is More" appeared in our October 1999 issue.*

THE SKY SHOW

February may be the shortest month, but it's filled with observing opportunities.

by Martin Ratcliffe and Alister Ling

A crisp, frosty, February night presents a spectacular sky. A simple step outside the house into the winter's darkness will dazzle you this month. The brilliant stars of Orion and his neighbors stand high in the south after sunset. High in the west-southwest, Jupiter shines as the brightest object in the night sky, except for the moon. The true spectacle of the winter sky requires a trip away from city lights. Depending on where you live, this can take anywhere from a drive of a few minutes or two hours — such are the penalties of living in suburbia with its attendant streetlights. A trip into the star-studded darkness of a winter's night revitalizes the spirit in a way no other sight can. Go ahead — give it a try. You may even spot the northern lights while you're out there.

Fabrizio Melandri

This time-lapse photograph shows Mars and Regulus trailing over the snowy mountains of Italy and reflecting into the dark waters of Lake Scaffaiolo below.

Mercury, the innermost planet, can best be seen about an hour after sunset between February 10 to 20 — look low in the west during dusk. However, you don't have to wait that long to see it. On February 6, try catching a glimpse soon after sunset when a one-day-old crescent moon glides to the left of Mercury. The sky will be bright, so use binoculars to focus in on the moon, and the magnitude –1 planet should be an easy object just 2° to its right. Make sure you do this *after* sunset to protect yourself from accidentally viewing the sun through binoculars — this would severely damage your eyes.

Two days later, on February 8, the growing crescent moon stands 4° away from magnitude 1.2 **Mars**. The Red Planet continues its very slow slide toward the sun and will not reach solar conjunction until July 1. Currently it lies at the western end of Pisces the Fish.

Regular readers will have no problem identifying the next planet on our nightly tour. **Jupiter** has dominated the sky ever since last fall. For most of the month it shines brilliantly at magnitude –2.2 on the Pisces/Aries border. Ideally placed for

2 Asteroid Iris is at opposition, 1 A.M. EST
The moon passes 1.4° north of Venus, 10 A.M. EST (page 69)

5 New moon is at 8:03 A.M. EST; partial solar eclipse

6 Uranus is in conjunction with the sun, 2 A.M. EST
The moon passes 1.8° south of Mercury, 2 P.M. EST

8 The moon passes 4° south of Mars, noon EST

10 The moon passes 4° south of Jupiter, 9 P.M. EST

11 The moon passes 3° south of Saturn, 7 P.M. EST

12 First quarter moon is at 6:21 P.M. EST

13 The moon passes 1.2° north of Aldebaran, 10 P.M. EST

14 Mercury is at greatest eastern elongation (18°), 8 P.M. EST (page 67)

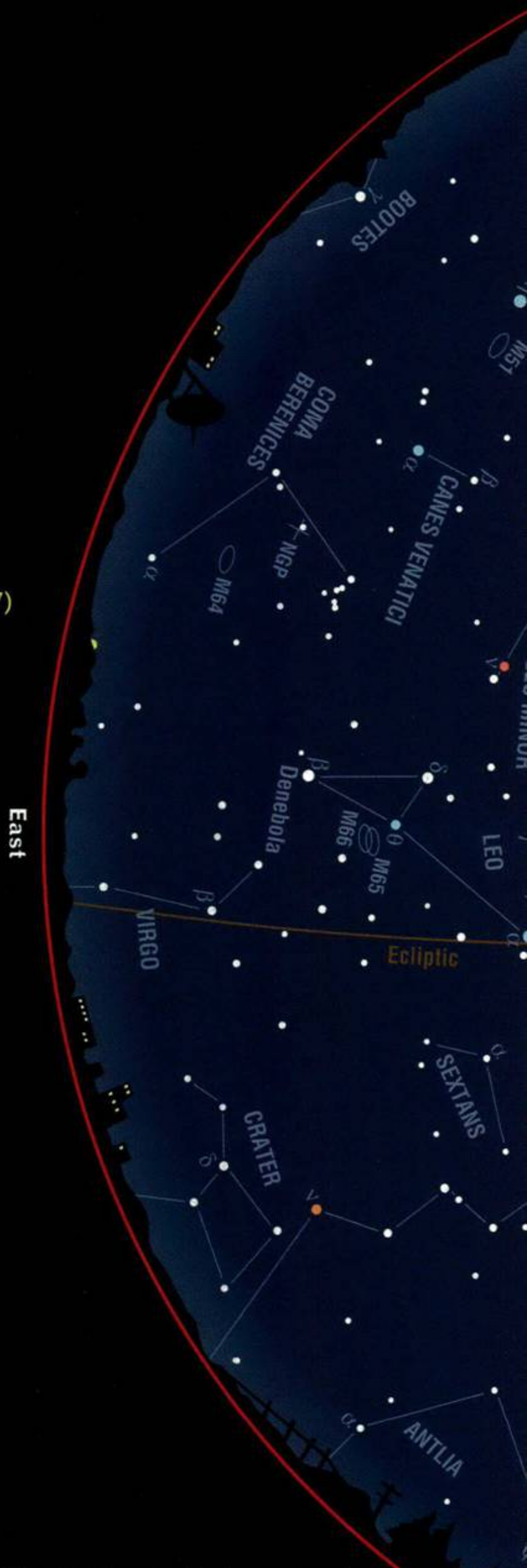
16 The moon is at perigee (226,486 miles from Earth), 9:33 P.M. EST

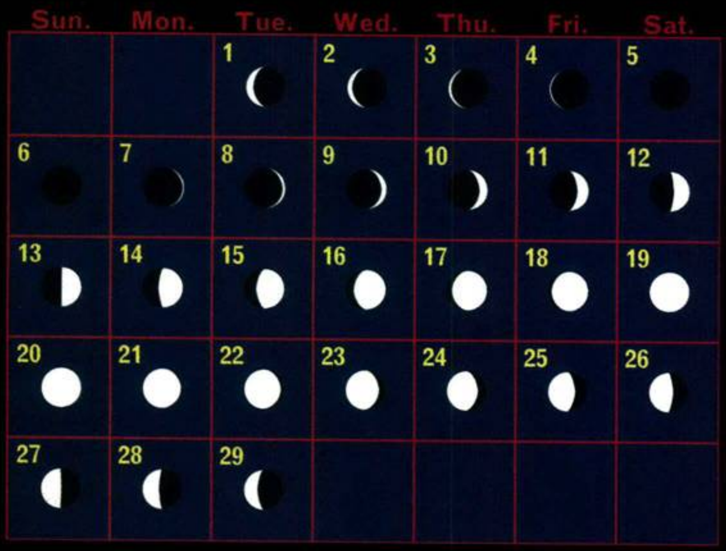
19 Full moon is at 11:27 A.M. EST

22 Venus passes 0.5° south of Neptune, 1 A.M. EST

26 Last quarter moon is at 10:53 P.M. EST

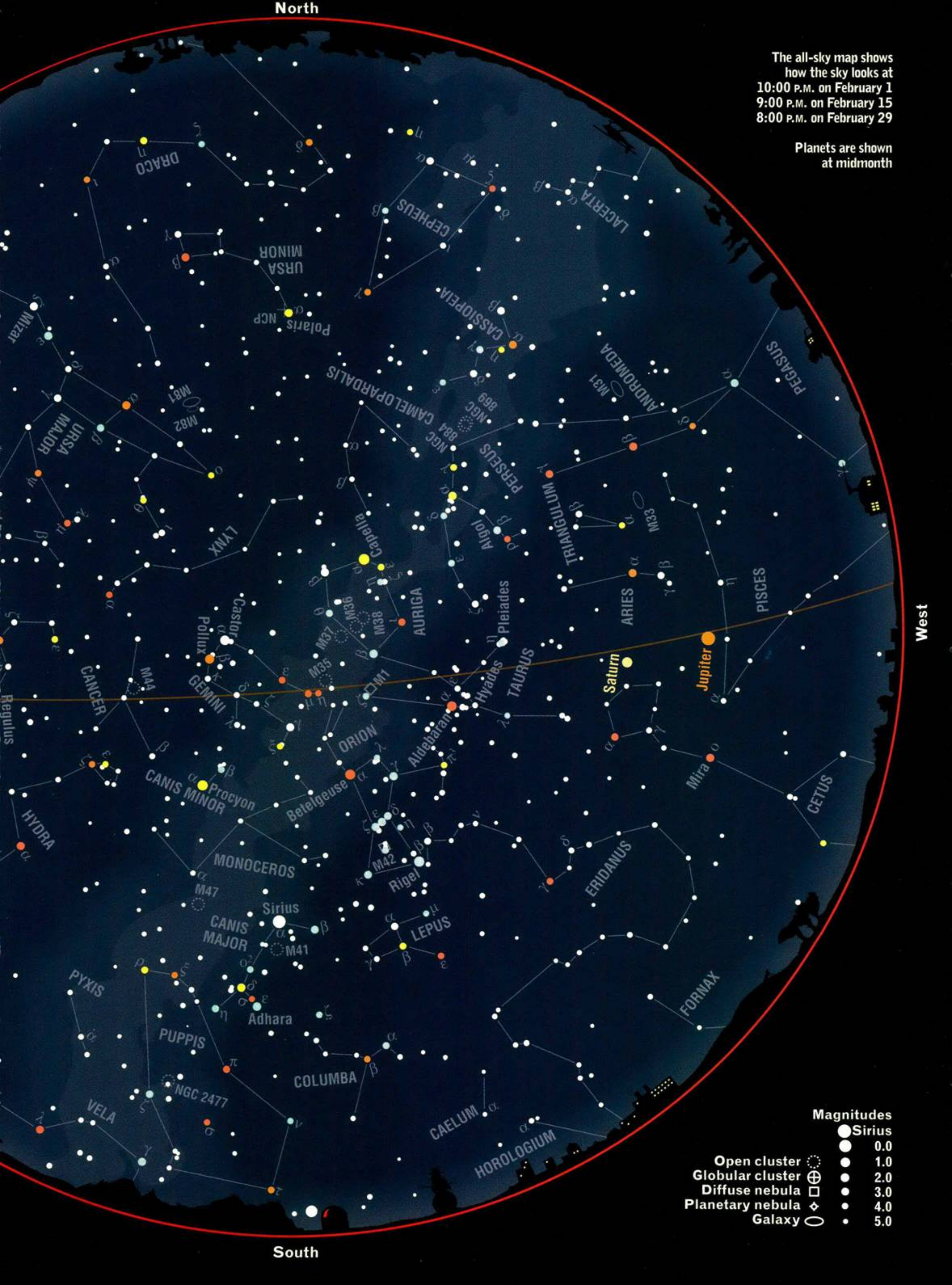
28 The moon is at apogee (251,416 miles from Earth), 3:46 P.M. EST





Sun.	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29				

This map portrays the sky at times shown in the upper right corner of the page. Located just outside the map are the four directions: north, south, east, and west. To find stars above your horizon, hold the map overhead and orient it so a direction label matches the direction you're facing. The stars above the map's horizon now match what's in the sky.



The all-sky map shows how the sky looks at
10:00 P.M. on February 1
9:00 P.M. on February 15
8:00 P.M. on February 29

Planets are shown at midmonth

North
DRACO
CEPHEUS
LACERTA
URSA MINOR
Polaris
NCP
CASSIOPEIA
ANDROMEDA
PEGASUS
M31
CAMELOPARDALIS
NGC 869
NGC 884
M81
M82
URSA MAJOR
Mizar
PERSEUS
TRIANGULUM
M33
Algol
LYNX
Capella
AURIGA
M36
M38
M37
Pleiades
ARIES
PISCES
Castor
Pollux
M35
M1
Hyades
TAURUS
Saturn
Jupiter
West
CANCER
M44
GEMINI
Regulus
Aldebaran
ORION
Mira
CETUS
CANIS MINOR
Procyon
Betelgeuse
HYDRA
MONOCEROS
M42
Rigel
ERIDANUS
M47
Sirius
CANIS MAJOR
M41
LEPUS
PYXIS
Adhara
FORNAX
PUPPIS
COLUMBA
NGC 2477
VELA
CAELUM
HOROLOGIUM
South
Magnitudes
Sirius
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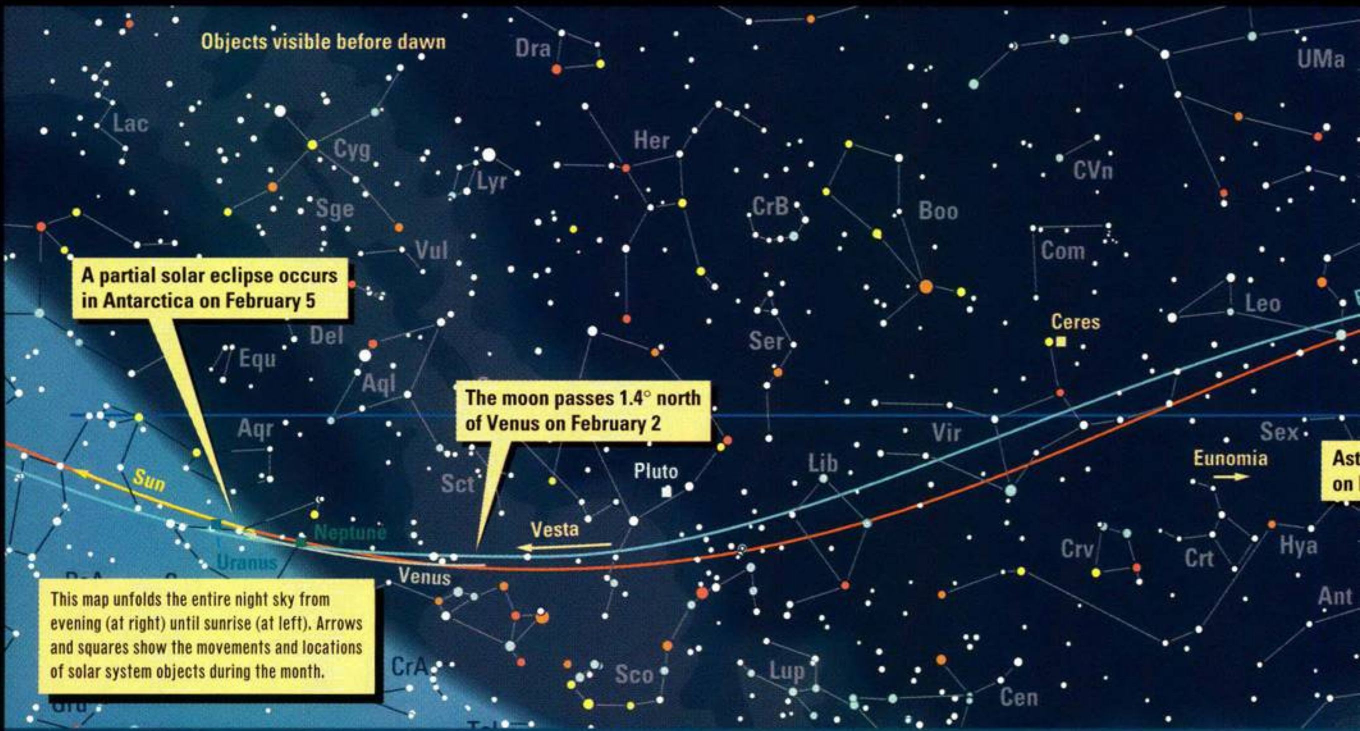
2.0
3.0
4.0
5.0
Open cluster
Globular cluster
Diffuse nebula
Planetary nebula
Galaxy

THE PATH OF THE PLANETS



Lac
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Com
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Ceres
Ser
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Aql
Aqr
Sun
Neptune
Uranus
Sct
Venus
Vesta
Pluto
Lib
Vir
Sex
Eunomia
Crv
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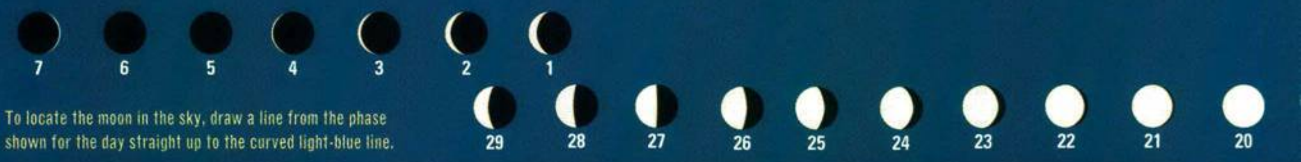
Objects visible before dawn

A partial solar eclipse occurs in Antarctica on February 5

The moon passes 1.4° north of Venus on February 2

This map unfolds the entire night sky from evening (at right) until sunrise (at left). Arrows and squares show the movements and locations of solar system objects during the month.



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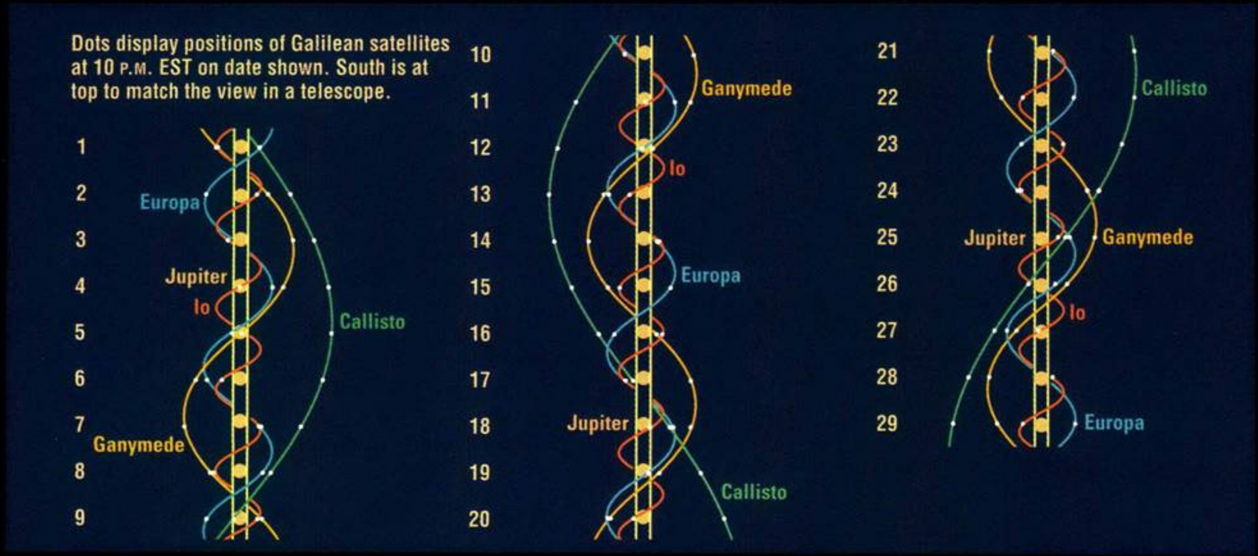
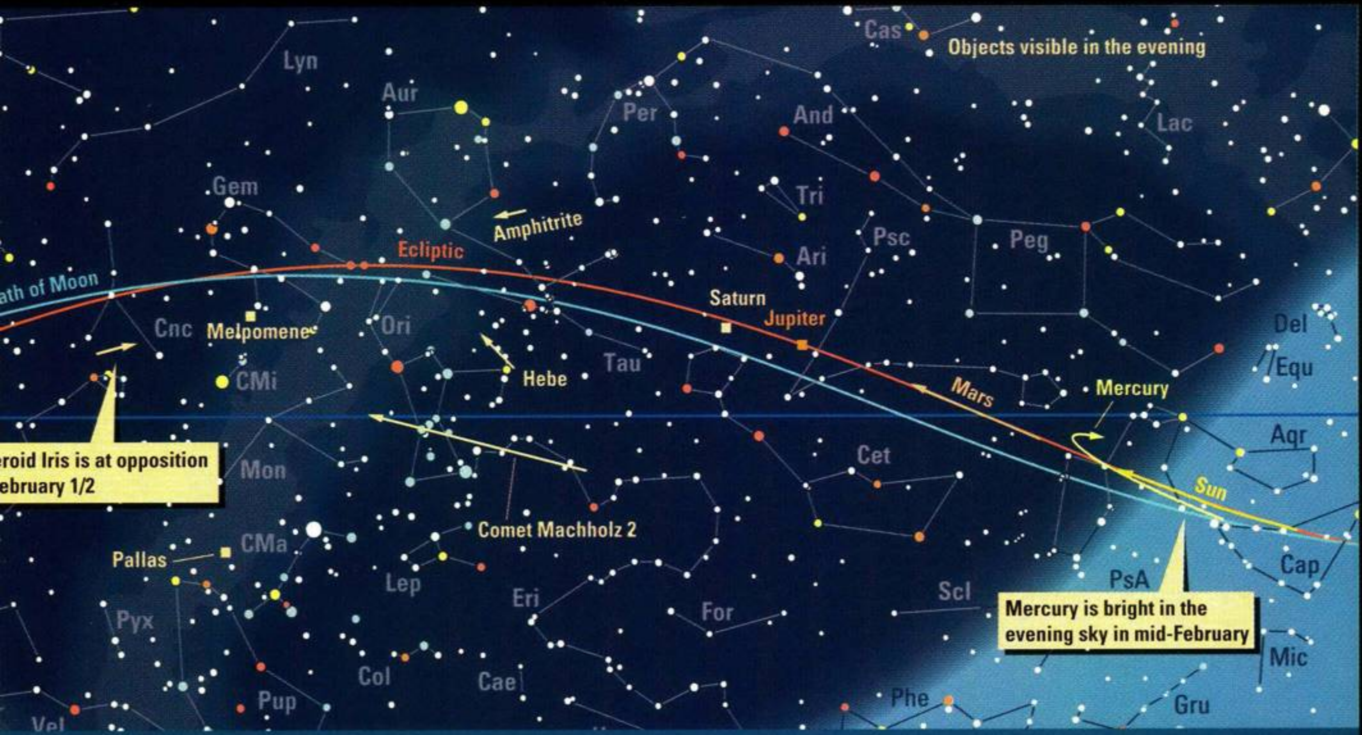
To locate the moon in the sky, draw a line from the phase shown for the day straight up to the curved light-blue line.

PLANETS	MERCURY	MERCURY	VENUS	MARS	JUPITER
Date	February 1	February 15	February 15	February 15	February 15
Magnitude	−1.1	−0.5	−4.0	1.2	−2.2
Angular Size	5.3"	7.1"	11.9"	4.5"	37.1"
Illumination	92%	51%	87%	96%	99%
Distance (AU) from Earth	1.273	0.945	1.398	2.091	5.318
Distance (AU) from Sun	0.362	0.308	0.726	1.426	4.972
Right Ascension (2000.0)	21h41.8m	22h58.6m	19h52.2m	0h09.1m	1h53.2m
Declination (2000.0)	−15°31'	−5°32'	−20°51'	0°27'	10°29

JUPITER'S MOONS



Dots display positions of Galilean satellites at 10 P.M. EST on date shown. South is at top to match the view in a telescope.


Cas
Objects visible in the evening
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Per
And
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ath of Moon
Saturn
Jupiter
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Cnc
Melpomene
Ori
Equ
Hebe
Tau
Mars
Mercury
CMi
Aqr
Cet
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Comet Machholz 2
CMa
Pallas
Cap
Lep
PsA
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Scl
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Pyx
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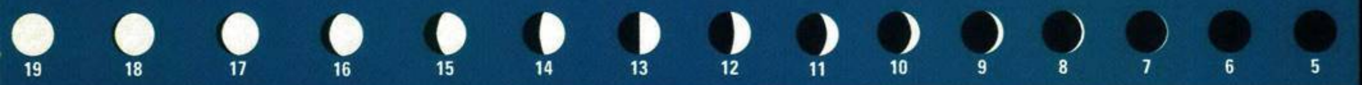
eroid Iris is at opposition
ebruary 1/2

Mercury is bright in the evening sky in mid-February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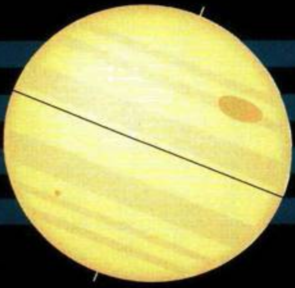
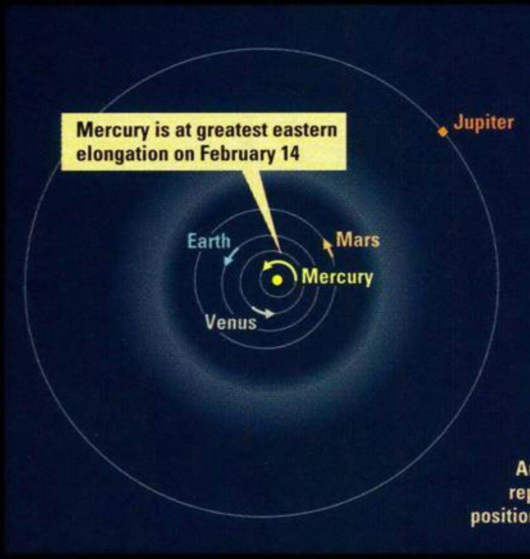


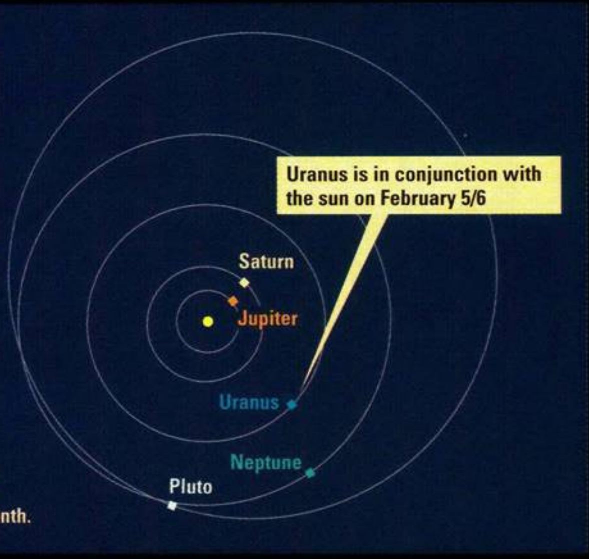
SATURN	URANUS	NEPTUNE	PLUTO
February 15	February 15	February 15	February 15
0.3	5.9	8.0	13.8
17.7"	3.4"	2.2"	0.1"
100%	100%	100%	100%
9.368	20.905	31.040	30.506
9.174	19.928	30.119	30.237
2h38.5m	21h19.9m	20h28.6m	16h50.5m
13°07'	−16°16'	−18°50'	−11°24'

THE PLANETS IN THEIR ORBITS


Jupiter
Earth
Mars
Mercury
Venus

Mercury is at greatest eastern elongation on February 14

Arrows and dots represent planets' positions during the month.


Saturn
Jupiter
Uranus
Neptune
Pluto

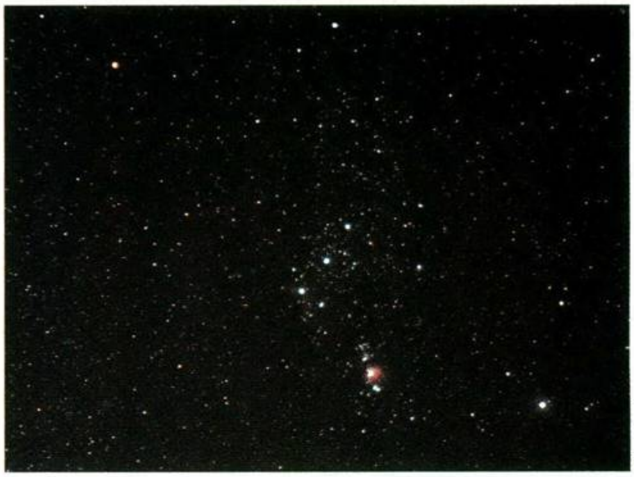
Uranus is in conjunction with the sun on February 5/6

First Views: Orion's Belt and Sword

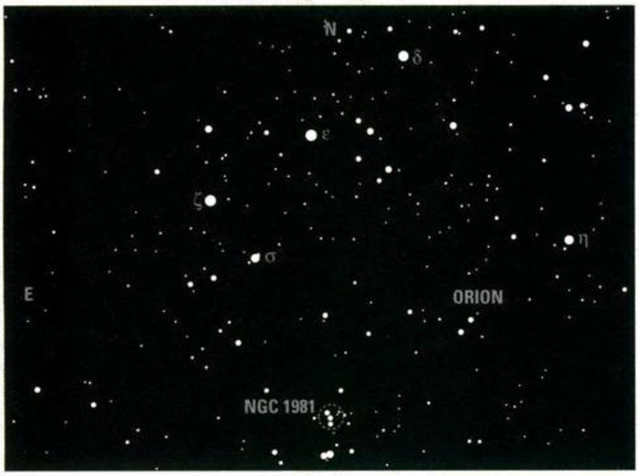
Orion's magnificent belt and sword region are rich in bright stars, clusters, and gas clouds, all visible from big-city suburbs, making it a top destination for binocular observers.

The three bright belt stars are all young, hot, and blue-white. Astronomers classify them as B-type stars, near the top of the temperature scale. Like all massive stars, they burn quickly and will exhaust their energy supplies in a few million years. Through binoculars you can see a profusion of stars in and around the belt. Only in this century astronomers recognized that this area is a cluster, now cataloged as Collinder 70. Can you spot its large, winding "S" shape?

Scanning south will land you smack on Orion's Sword, including its stellar nursery. Long known to the ancients as a misty "star," the great Orion Nebula (M42) displays its wonderful world of gas, dust, and stars, especially when viewed with binoculars. Take time to notice how its southern edge appears soft compared to the sharp-edged northern border. The bright, infant stars have not yet ionized the large amounts of obscuring dust and gas that reside in the northern abyss.



Robert Fredl



All illustrations: *Astronomy*/ Elisabeth Rowan

Any small telescope will show the heart of the Orion Nebula as a group of four bright stars known as the Trapezium. It's a very pretty sight. If you spend some time studying the cocoon of nebulosity surrounding the Trapezium, you'll notice that it has all sorts of interesting texture. The Trapezium stars are so hot that they ionize the surrounding gas and make it shine by fluorescence.

Moving north a bit, you'll see a handful of stars enshrouded in a faint swath of reflection nebulosity. Here the stars are cooler and cannot ionize the gas, so surrounding dust glows dimly in the scattered starlight. The topmost clump in Orion's sword is an open cluster designated NGC 1981. Binoculars show it as a fuzzy spot.

Make Orion your first observing stop during winter evenings. Every moment can reveal new, subtle characteristics that you've never seen before.

---

early evening viewing, it stands high in the west after sunset. Some of the best telescopic views of Jupiter can be had by observing the planet during twilight. The planet's four Galilean moons are also easily visible through small telescopes in twilight. Jupiter's disk carries a complex amalgam of zones and belts that are worthy of some extended viewing. During brief moments of steady seeing that occur as the atmosphere settles, the view of Jupiter is breathtaking.

Watch the features each night as they cross the visible surface. Be mesmerized by the meanderings of the moons back and forth in front and behind the disk of Jupiter as they trace out their individual paths. If you are steadfast in your observations, you may even notice the 1–2–4 orbital synchronicity of Io, Europa, and Ganymede.

On February 10, Jupiter lies 4° north of the moon. The pair sinks toward the horizon, with Mars leading their way.

Saturn resides almost 10° higher than Jupiter, dimmer than mighty Jove at magnitude 0.5 but still easy to spot in this relatively sparse region of sky. Again, telescopically the views are awesome — especially in twilight when the Ringed Planet appears so delicate. The southern face of the rings tilts toward us by 20° and the planet spans 16". The long axis of the rings extends almost triple that distance. Titan, the largest and brightest of Saturn's 18 moons, orbits the planet in 16 days. From February 1–3 and February 17–19 you'll find this magnitude 8.3 saturnian moon to the east of the planet. On Valentine's Day (February 14), Titan lies due south, and on February 6 and 22 it lies due north of Saturn. (For more details, see "Tailing Titan and Iapetus," page 67.)

Along with the bright planets in the western sky, the autumnal constellations are slowly sinking as the evening passes into night. The Great Square of Pegasus swings low into the northwest, with Andromeda following. Pisces dips in the west, joined by Cetus the Whale. The winding constellation Eridanus the River flows almost endlessly from Orion down to the southwestern horizon. Orion fills the southwestern sky with overwhelming beauty, surrounded by the throngs of bright stars in adjacent constellations.

Imagine a swollen star spanning more than 400 times the diameter of the sun, so large that its outer layers are more rarefied than the gases in Earth's atmosphere. If such a star replaced the sun, it would stretch beyond the orbit of Mars. If you moved this star 540 light-years away, at a distance from which the sun would be invisible, the star would still shine brightly across the 3,000 trillion miles of space — but now it would be seen as a point of light. And that's exactly what we see when looking at the star at the upper-left part of Orion that marks his shoulder, the bloated red-giant Betelgeuse.

A star of similar importance to Betelgeuse lies in the opposite corner of Orion, the contrasting bluish-white Rigel. At almost double Betelgeuse's distance from Earth and accounting for the inverse-square law that states that an object at double the distance will appear four times fainter, Rigel paradoxically appears to be of a similar magnitude as Betelgeuse.

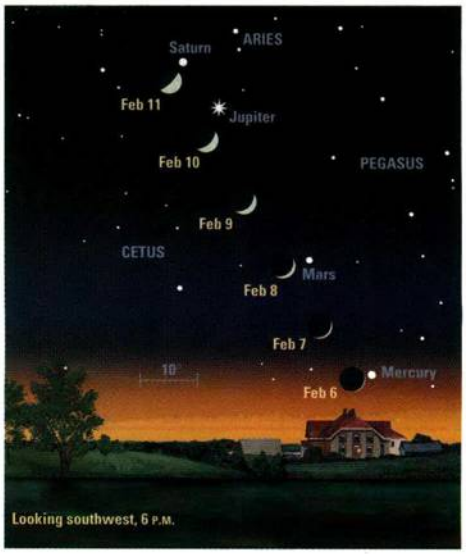
The answer to this apparent dilemma is simple: Rigel is even more of a powerhouse than giant Betelgeuse, radiating four times as much light as its neighbor. Suddenly, Orion no longer appears as a flat object, but its three-dimen-

A Planetary Chorus Line

If there's one week to introduce the sky to relatives, neighbors, and coworkers, it's January 6 to 12. The eye-catching lineup of bright planets in the evening sky will be joined by a spectacular waxing crescent moon.

Begin 40 minutes after sunset on the 6th to snag the thin crescent moon half a binocular field to the left of a bright point of light — the innermost planet Mercury (see Mercury's Bright Night Outing, page 67). On the 8th, fading Mars lies about one field of view to the right of the moon. By the 10th, Jupiter stands as a jewel above the lunar arc. The next evening will look similar, only this time Saturn will be the moon's dance partner.

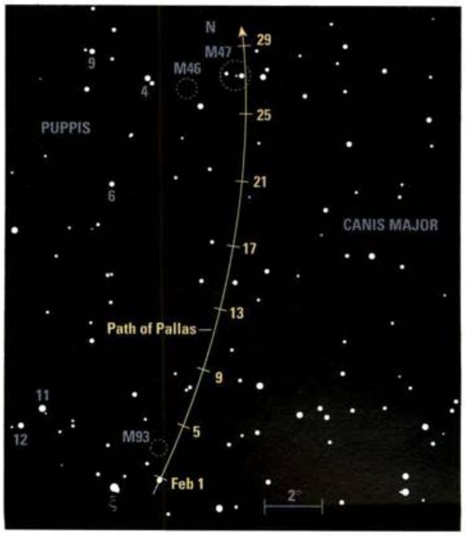
Watch Saturn and Jupiter close in on Mars over the upcoming weeks.



Pallas in Puppis

There's nothing like asteroid hunting to carry you across interesting swaths of sky. This month a few open star clusters, including M93 and M47, lie near the path of the second asteroid to have been discovered, Pallas.

Pallas really stands out compared to other asteroids because it strays considerably from the beaten path. With a very high inclination of 35°, it plunges through the ecliptic, that level field in which the planets and asteroids orbit.



Pallas's 7.5 magnitude will help you spot it against the Milky Way starfields of Puppis, just to the left of Canis Major. From the 2nd to the 4th, Pallas is less than 30' (one moonwidth) west of M93. This group of modestly bright stars stands out well even in light-polluted skies. Pallas will appear a half magnitude brighter than M93's most luminous stars.

On the evenings of February 27 and 28, Pallas glides 15' west of M47, which is even more splashy than M93. Return after one hour, and you should easily be able to see that Pallas has moved relative to the numerous background stars.

If you enjoy asteroid hunting, then try observing asteroid occultations, when one of these space rocks moves in front of a star and makes it disappear for a few seconds. Just about every couple of months an event occurs not far from you. Check out the IOTA web site at http://www.lunar-occultations.com/iota/iotandx.htm for maps and charts. One such event on the 26th occurs close to a path from eastern North Carolina through Duluth and into central Alberta, when asteroid 44 Nysa at magnitude 10.2 is predicted to cover a magnitude 9.3 star for up to 25 seconds.

sionality comes alive. Many planetariums now exploit this knowledge by "flying around" such star groups using a digital star projection system called Digistar.

Turn your attention to the northeastern sky to find the asterism of the Big Dipper (in Ursa Major) rising higher each evening. At the same time, watch for Leo the Lion rising due east, led first by the bright, 1st-magnitude star Regulus and the associated stars nearby that form the familiar sickle (backward question mark). Gemini stands high above Leo and contains the moon on February 15 and 16. Auriga the Charioteer passes overhead, with Perseus leading the way toward the northwest. Cassiopeia sinks in the northwest as Ursa Major rises in the northeast, all circling around the North Celestial Pole, approximately marked by the magnitude 2.1 star Polaris.

The moon joins the myriad of winter stars during these cold February nights, wandering across the sky. Careful study of the moon reveals its hourly, slow motion from west to east relative to the starry background. Occasionally the moon passes in front of a star, causing an occultation. Such lunar occultations are fascinating to watch. Try timing the stars' disappearances using a short-wave radio that can pick up WWV Fort Collins. This radio station transmits a 24-hour time signal at 2.5, 5, 10, 15, and 20 MHz.

An easy occultation occurs on February 17, when the moon crosses in front of Delta (δ) Cancri, a 4th-magnitude star. The event, visible even with tripod-mounted binoculars,

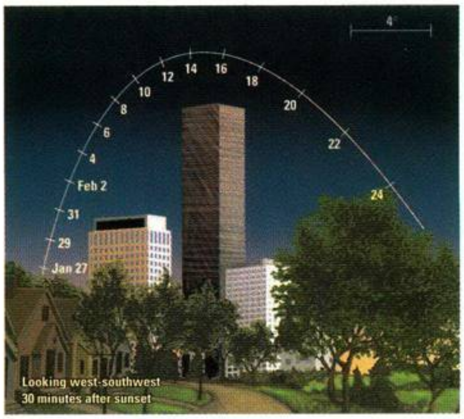
Mercury's Bright Night Outing

Mercury is often incorrectly touted as being difficult to find because it moves so fast. Its brief foray into the evening sky this month will also be notable for its speed — in how quickly it changes in brightness. In a matter of 10 days, it fades by two magnitudes.

You can locate Mercury easily, for it lies almost directly along a line from Saturn, through Jupiter and Mars, down to the horizon. The key to finding the inner planet is to have a view that's free of trees and buildings. For many readers, Mercury will stand only a half to one fistwidth at arm's length (5° to 10°) above the horizon in the twilight glow some 45 minutes after sunset.

The dramatic change in brightness can be easily tracked over a span of two weeks. On the 10th, Mercury shines at magnitude –0.9, and within 5 days, it has dropped to –0.4. By the 20th, Mercury has plunged to magnitude 0.7. Only two evenings later, the speck of Mercury shines with a feeble magnitude 1.4, fainter than nearby Mars.

Mark your calendar for the 6th, when the thin crescent moon, painted with earthshine, stands a bit more than 2° to the left of Mercury, about half a binocular field of view away.

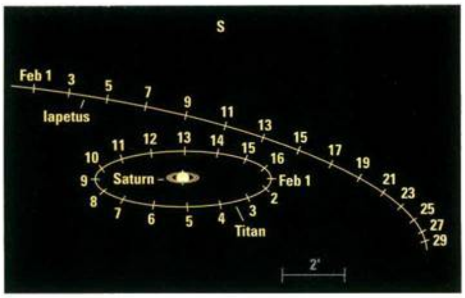


Looking west-southwest
30 minutes after sunset

Tailing Titan and Iapetus

Saturn captures the imagination thanks to the beauty of its rings, but the often overlooked moons in the saturnian system also make pleasurable viewing destinations. Set your sights on the satellites Titan and Iapetus.

The smallest telescopes can easily bag the giant, enigmatic moon Titan. In a few years the Cassini probe will enter Titan's atmosphere, making the present view a little less mysterious. Through the eyepiece, Titan, the second largest moon in the solar system, looks like a magnitude 8.4 "star" — typically the brightest point in the field of view. Check the map below to be positive you've got it.



Iapetus belongs on any list of strange bodies in the solar system. Like Earth's moon, it rotates once for every time it circles Saturn. But Iapetus's leading face is covered in an unknown dark substance, while the trailing half remains bright, icy white. This means that at the start of the month, Iapetus glows at nearly 10th magnitude, but by a month later it will have faded to about 12th magnitude. An 8-inch scope does a fine job of following this change in brightness.

On the 2nd, Iapetus swings close to a 10th-magnitude field star. See if you can note its positional change over an hour's time. On the 8th, an 8th-magnitude star provides a good benchmark just south of Iapetus; a 10th-magnitude star lies just north on the 22nd.

The chart shows the position of Iapetus and Titan at one day intervals, at 7 P.M. EST. North is down, to match the view in a Newtonian reflector. Schmidt-Cassegrain telescope or refractor owners with a diagonal can photocopy the chart, flip it over, and shine a flashlight through the front side.

OBSERVER'S CHALLENGE: Orion's Children

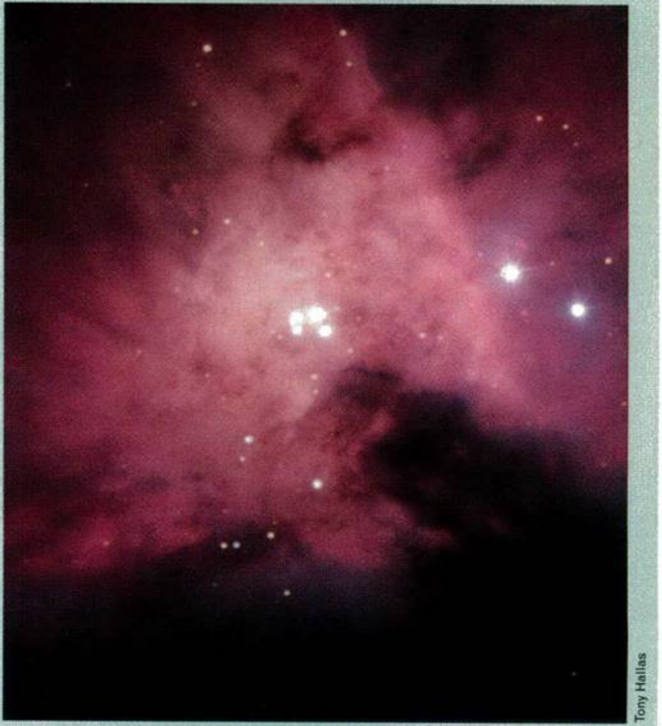
Only one place in the sky can rival the stunning view at the heart of Orion's nursery. For those of us in the Northern Hemisphere, the Eta Carinae Nebula is out of reach, leaving us the core of the Orion Nebula (M42) as the ultimate sight.

On a steady night, the wealth of detail in this cauldron of creation can be challenging to describe. Use magnifications over 200x to see it all. Make sure you allow your scope to cool down in the chilly air, otherwise the turbulence you see will be in your tube, instead of in the fluorescing interstellar gas.

The smallest telescopes reveal the four bright stars known as the Trapezium. These stars are designated Theta^1 (θ^1) Orionis A, B, C, and D. A patient eye behind a 4- to 6-inch scope will reward you with two fainter specks, called E and F. The joy of getting to see these babies makes for a delightful surprise. For some it may take larger telescopes on a very dark night to discover them, but patience and knowing exactly where to look helps immensely.

The most important skill to have is perseverance. An unsteady night, even with a 12-inch telescope, will only lead you to disappointment. Keep trying and one night with a small scope they will be so obvious you'll wonder why it took so long for them to be discovered by the great observers Struve and Herschel. Use a mask with an off-center hole if you have a big scope.

Many stars in the nearby region are in the neonatal unit of Orion's nursery. More than a dozen rapidly fluctuating variable stars are buried in the region's dust, whose vital signs change by as much as a magnitude during the night. Experienced variable star observers enjoy monitoring them.


Tony Hallas

The intricate tapestry of the cocooning nebula will enrapture avid cloud observers and beckon the astrophotographer. Here, too, patience will reward you with rare glimpses of incredible detail. Herschel's words have yet to be surpassed: "I know not how to describe it better than by comparing it to a curdling liquid, or to the breaking up of a mackerel sky."

occurs around 9 P.M. CST for observers located in midwestern states. For observers farther west, the event takes place earlier, and for those in the eastern United States it occurs later. On February 11, the moon swings by Saturn and occults Mu (μ) Ceti at the same time. Check with your local astronomy club or http://www.lunar-occultations.com/iota/iotandx.htm for more detailed predictions of these and other interesting occultations throughout the year. (For information on an asteroid occultation, see "Pallas in Puppis," page 66.)

The early bird catches the worm, or in this case, **Venus,** which lies in the morning sky before sunrise. On February 1, Venus rises two hours before the sun, and a 26-day-old waning crescent moon stands about 12° away.

The following morning will be full of activity, and not just from the pairing of Venus and the moon. February 2 is called Candlemas, or better know these days as Groundhog Day. The saying went, "If Candlemas be fair and bright, Come, Winter, have another flight; If Candlemas bring clouds and rain, Go, Winter, and come not again." Many of the early risers on this holiday who are heading out to see the groundhog may glimpse Venus and an 8-percent-lit moon hovering nearby; they lie less than a degree apart — a beautiful pairing among the stars of Sagittarius low in the southeast.

Venus falls rapidly into the morning twilight, becoming harder to see, though its brilliant magnitude of –3.8 makes it stand out longer than any other planet would in a similar situation.

Of mere academic interest, Venus passes just half a degree south of **Neptune** on February 22, but unfortunately the event occurs in a bright sky and Neptune will not be visible.

Uranus reaches conjunction with the sun on February 6 and moves into the morning sky, becoming visible in late March and early April.

If you like spiral galaxies, by the end of February an interesting grouping rises in the east. The tail of Leo the Lion almost seems to point the way. With only a 3-inch telescope, you can find the bright, tilted spiral galaxy M88 in Coma Berenices; it is the northeastern point of a stunning archipelago of galaxies known as Markarian's Chain.

The mythology of Coma Berenices, Berenice's Hair, bears repeating. When the king of Egypt went off to war, his beautiful young wife, Berenice, promised to give her gorgeous locks of hair to the goddess Venus in return for a safe homecoming for her husband. When the king returned, Berenice cut off her tresses and placed them in the temple. When the locks disappeared, the temple guards were threatened with execution for their negligence. But the astronomer Conon saved their lives by pointing to the glittering arc of stars in the sky and claiming them to be Berenice's hair, transported to the heavens.

The shorter days of winter still allow for some good solar observing, just so long as you take suitable precautions for safe viewing. Ideally, project an image of the sun onto a piece of white card, and you will almost assuredly see sunspots this month. The sun should reach the maximum of its 11-year cycle of activity this year. Numerous sunspots will dot the surface and change shape daily.

If you're an amateur astronomer born in February, then you're in good company. Pluto discoverer Clyde Tombaugh was born on February 15, 1906; Galileo was born on February 15, 1564; and Nicolas Copernicus was born on February 19, 1473. ▪

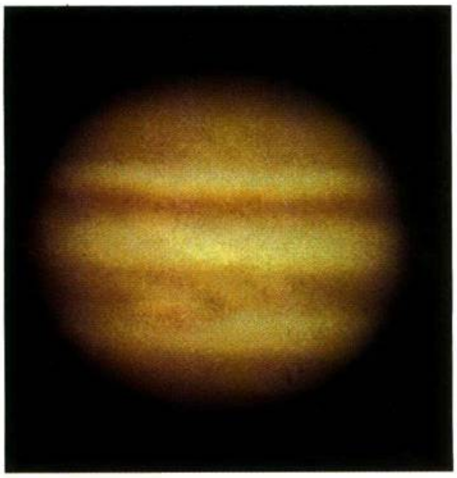
Martin Ratcliffe is Director of Theaters at the Exploration Place in Wichita, Kansas. Alister Ling is a meteorologist working for Environment Canada in Alberta.

Following Jupiter's Great Red Spot

The Great Red Spot has a special charisma that extends beyond its colorful history. On a planet with roiling cloud bands and ephemeral wisps, the spot holds its own in a chaotic dance. You can even see it in a 4-inch telescope when conditions are steady.

Sometimes nicknamed the Great Pale Spot because of its last decade of whiteness, the cyclonic storm can be a challenge. Back in the '60s, it was described as "brick red" in 2.4-inch (60mm) instruments. If you know in advance when to look for it, you'll avoid common frustrations.

2 Feb 2000 5:38
3 Feb 2000 1:30
4 Feb 2000 7:17
5 Feb 2000 3:09
7 Feb 2000 4:48
8 Feb 2000 0:40
9 Feb 2000 6:27
10 Feb 2000 2:19
11 Feb 2000 8:06
12 Feb 2000 3:58
14 Feb 2000 5:37
15 Feb 2000 1:29
16 Feb 2000 7:17
17 Feb 2000 3:08
19 Feb 2000 4:47
20 Feb 2000 0:39
21 Feb 2000 6:27
22 Feb 2000 2:18
24 Feb 2000 3:58
26 Feb 2000 5:37
27 Feb 2000 1:29
28 Feb 2000 7:16
29 Feb 2000 3:08


Thomas Endemann

Above you'll find a table of the Great Red Spot's transits — when it lies across the middle of Jupiter's north-south line. The best seeing occurs within an hour of either side.

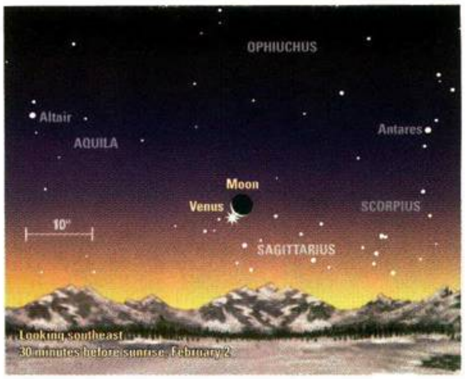
Remember that the spot lies on the edge of the southern temperate belt; nudge your scope southward to see the south limb disappear last. Events listed are visible from the Americas and in UT. (Subtract 5 hours for EST, 6 for CST, 7 for MST, and 8 for PST.)

One advantage of guide software is that it actually plots the Great Red Spot in the right place on Jupiter, as well as generating the table of events for your time zone.

The Morning Star

This time last year, Venus was the prominent evening star, sharing the stage with Saturn and Jupiter. Now it stands alone in dawn's sky, in the fading days of its morning career. After mid-month, Venus will be getting tough to see, sinking lower and lower each day into the bright morning twilight.

Don't miss its spectacular pairing with a thin, waning crescent moon on the morning of the 2nd. From the east coast of North America, Venus will be only two moon diameters (1°) to the lower left. In another three hours, when those on the west coast get their chance, the moon will have crept its whole width closer.



Because Venus lies on the farside of the sun this month, its fat, gibbous phase (85 percent lit) shows a disk approaching full illumination. We won't be seeing the return of the evening star again until mid-October.

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The Deep Sky: An Introduction

By Philip S. Harrington

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Capture the Sky on a CCD

Digital imaging with a CCD camera is revolutionizing the way amateur astronomers record planets and galaxies.

by Gregory Terrance

Once upon a time, amateur astronomers who wanted to capture portraits of the sky went to the local pharmacy; bought a roll of film; dusted off their 35mm camera, tripod, and telescope; and shot long exposures to catch a glimpse of faint starlight. But as we close in on an a new millennium, the whole landscape of astroimaging is forever transforming. Analog imaging is no longer the only method of choice; film has moved aside to welcome its high-tech cousin, digital imaging, as a significant way of capturing stars, planets, and galaxies. Film-based astrophotography still has its place, mind you: It's easier than ever to do, and films today are faster and sharper than their ancestors. But for many goals, digital imaging has become the method of choice. As the years roll on and the electronics that power digital imaging become ever more sophisticated and cheaper, the sway it holds over amateur astronomers will only continue to rise.

Inside the CCD Chip

The boom in digital imaging has its roots with the military, as many technological innovations do, and has really blossomed with the swelling market for camcorders and digital cameras. These devices, which replace the camera loaded with film, employ a charge-coupled device (CCD) — a silicon

The Andromeda Galaxy and its two brightest satellites gleam in a mosaic made with a 4-inch refractor and an SBIG ST-8 CCD camera. Robert Gendler

Which Camera Is for You?

Although five companies compose the principal makers of CCD cameras for astroimaging, each company produces as many as seven models, and each model may be offered with slight modifications to suit a particular imaging need.

Your best bet in choosing a camera is to firmly decide what types of objects you are interested in capturing, thinking clearly about the telescope and computer systems you will use with it and the budget you must live with. Then explore the manufacturers' web pages, where the details may be found, and talk to them about the specifics of your system.

The larger the chip the better, generally speaking, but of course larger arrays will cost much more than smaller ones.

Apogee Instruments
1350 North Kolb Road, Suite 120,
Tucson, AZ 85715, telephone (520)
290-8887, web page: www.apogee-ccd.com

Apogee offers a wide range of sophisticated cameras (including the AP-7, shown) that produce frames from 512 pixels square to 2,048 pixels square.

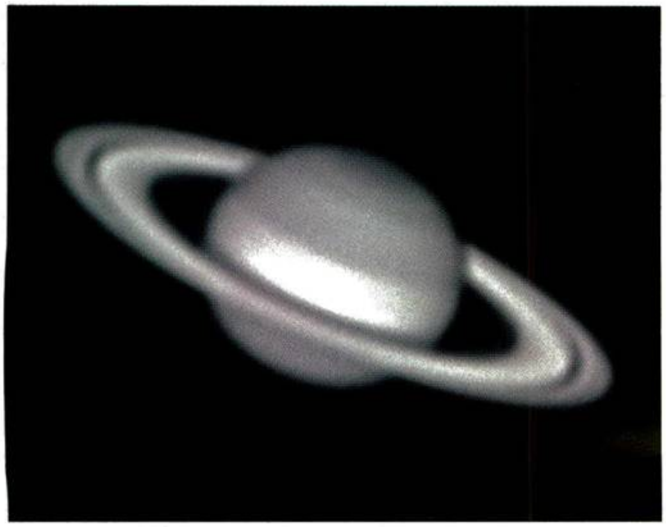
Finger Lakes Instrumentation
8031 Parker Hill Road, Dansville, NY
14437, telephone (716) 335-2506,
web page: www.fli-cam.com

FLI manufactures a line of seven CCD cameras with frame sizes ranging from 512 pixels square to 1,552 by 1,032 pixels, plus kits to build your own camera using various chips.

chip composed of an array of thousands or millions of picture elements called pixels. Each pixel acts as a little detector of light (normally 9 to 25 microns square) that receives a signal and converts the faint glow into electrons, typically at a quantum efficiency of 50 percent. The net result holds advantages over film. The waffle-like grid of pixels in a CCD chip offers advantages over film. A CCD's sensitivity, about ten times that of film, reduces the amount of exposure needed to record a given object.

Rather than spending 30 or 90 minutes photographing a faint galaxy, a CCD camera produces a satisfying result in 5 or 10 minutes. CCD detectors also offer precision in terms of recording light, making things such as measuring accurate brightnesses of stars in an image more feasible. They also provide nearly instant results; rather than tanks of smelly chemicals, CCD images require only a computer and software for processing. With a few clicks of a button, images can be processed and viewed in an instant. The CCD revolution is under full steam and limited only by the size and expense of chips, which still leave the edge to conventional photography in terms of imaging wide fields of sky and affordability. But the situation continues to develop rapidly, and larger chips will continue to be developed at cheaper prices, eventually making wide-field imaging feasible at an affordable cost.

CCD chips vary widely. Their sizes and configurations of pixels cover a great range. For most astroimagers, large CCDs are as desirable as large telescopes; larger CCDs have more pixels and produce higher-resolution images than smaller CCDs. Larger chips can also record larger areas of sky. Five manufacturers provide the principal CCD cameras offered to the amateur astronomy market today (see "Which Camera Is for You?," above). Their cameras range from 192 by 164 pixels (31,000 pixels over an array measuring 2.6 by 2.6 mm) to 1,530 by 1,020 pixels (1.5 million pixels over an array measuring 13.8 by 9.2 mm). Although "street prices" from dealers vary, the approximate ranges of cost for these cameras are $975 to $9,000, with the mid-range cameras that are quite capable of producing spectacular results coming in at about $1,500 to $2,000. Of course the computer (darkroom) and accompanying software (which typically comes along with the CCD cameras) must also be in place; they can be used either with PC or MAC platforms. Much larger arrays exist, many of those being used at professional observatories now measuring 2,048 by 2,048 pixels (yielding 4.2 million pixels),



Left: Saturn imaged on October 17, 1998, with a 20-inch reflector at f/20 and a Meade Pictor 416 XT camera. A. C. Tonkin
Right: Emission nebula IC 443 in Gemini shot with a 7-inch apochromatic refractor at f/6 and an SBIG ST-8 camera. David Hanon

Meade Instruments Corp.
6001 Oak Canyon, Irvine, CA 92620, telephone (949) 451-1450, web page: www.meade.com

The world's largest telescope maker offers an extensive line of Pictor cameras, autoguiders, and filter wheels. Frame sizes range from 336 by 242 pixels to 1,526 by 1,024 pixels.

Santa Barbara Instrument Group
1482 East Valley Road, #33, Santa Barbara, CA 93150, telephone (805) 969-1851, web page: www.sbig.com

The pioneering maker of CCD cameras for astronomy has a large line of cameras and autoguiders including simple (192 by 164 pixel) and complex (1,530 by 1,020 pixel) models.

Starlight Xpress

Starlight Xpress
Dist. in the U.S. by Adirondack Video Astronomy, 26 Graves Street, Glens Falls, NY 12801, telephone (518) 812-0025, web page: www.astrovid.com

This British-made line of cameras includes the MX-5 (shown) and other models including a "single-shot" color camera, with a range of chip sizes.

The full moon of December 14, 1997, was captured with a 7-inch apochromatic refractor at f/9 and an SBIG ST-8 camera. David Hanon

but they are frightfully expensive. This will change, however, as we have seen with all consumer electronics.

After the CCD detects light and converts the photons into electrons, creating an electronic signal, each pixel contributes to an exposure by "downloading" its information to the computer. Then the CCD, which is fixed in position at the focal plane of the telescope, is ready for another exposure. Once the digital "exposure" reaches the computer, it gets reassembled into the image that matches the photons the CCD "saw." The final step is processing the image with software on the computer, which will be outlined in a future article in this series. Image processing software that enables the basics comes with the cameras; final image processing can be done with Adobe Photoshop, which allows virtually any type of back-end image massaging.

Because of the silicon array that makes up the CCD, the camera must be cooled significantly to maximize its sensitivity, at least for exposures that last more than a couple seconds. CCDs suffer from dark current noise, which may be thought of as a tiny light leak in the system that can only be eliminated by cooling. CCD cameras typically come with equipment that allows chilling them considerably. Observatories might use liquid nitrogen, but the models sold on the amateur astronomy market are thermoelectrically cooled, sometimes with the assistance of fans or chilled, circulating water. If you want to record faint stuff, the colder the camera, the better.

Why Go Digital?

CCD cameras are adept at imaging all sorts of astronomical images — not just galaxies and nebulae, but close-ups of the moon and planets too. Not only do CCDs capture relatively small fields of view, which allows zeroing in on planets or small regions of craters, but they can produce many views of planets and lunar landscapes quickly, allowing you to handpick the frames that were snapped during moments of exceptionally crisp seeing.

This is possible because CCDs are "fast" (sensitive) compared to even the best photographic emulsions. A digital image of the Whirlpool Galaxy (M51), for example, might be made to a satisfying level of detail with a 6-inch f/5 reflector in as little as 2 minutes. With the same equipment, even very fast films would require a 20-minute exposure. The CCD's pixels are far more efficient at gathering and storing light than film's silver halide grains. You can digitally grab images in about 1/10th the time required to take an equally good film image, or you can shoot a 20-minute image with a CCD and capture far fainter outer nebulosity than you ever would with film, limited only by sky darkness.

Typically, films record 2 or 3 percent of the light that strikes them. By contrast, CCDs can record as much as 80 percent and certainly at least 50 percent of the light they encounter. The quantum efficiency of a particular chip depends on its design.

A CCD's virtues don't end with great sensitivity. A chip's linearity, its ability to record light at a constant rate, is just as significant. A 30-minute image made with a CCD yields twice the image density of a 15-minute CCD exposure. Conversely, photographic emulsions all suffer from reciprocity failure — decreasing sensitivity with time over long exposures — which means their efficiency takes a nosedive after the first few minutes. A "fast" ISO 1600 film will begin to act like a "slow" 100 speed film during a long exposure. CCDs avoid this pitfall and provide results that are accurate and predictable.

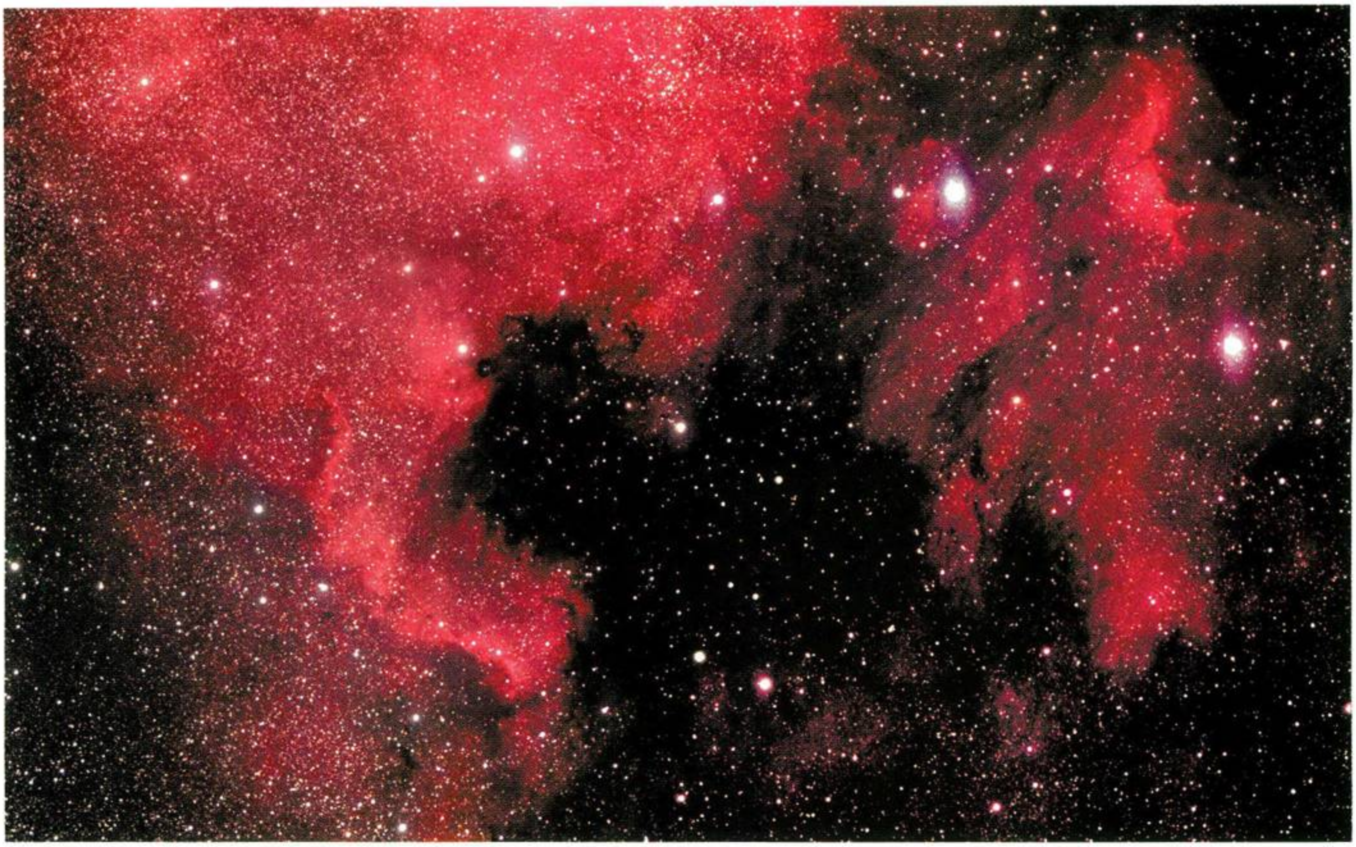
CCDs also respond to a broader range of wavelengths than film does. Their extended spectral response makes it possible for a digital camera to record objects that are invisible to photography. CCDs also have a tremendous dynamic range; they can record objects over vastly different levels of brightness in a single exposure.

Digital cameras operate in near real time. Though you may have to do a little image processing before an exposure is final, you can view raw CCD images almost instantly after taking them. This instant feedback is very helpful in working toward perfectly composed, sharply focused, high-quality results. With conventional astrophotography, you need to wait until getting the film back from the processor to see what happened, and this delay significantly lengthens the process of learning how to make good portraits. If there were focusing problems, it's too late to make adjustments.

CCD imaging also allows users to take control of the whole imaging process, from acquiring a target through final processing. Rather than relying on someone at a photo lab to make decisions about developing, the whole thing rests on you. If an image doesn't turn out the way you had hoped, you can simply make adjustments, go back, and shoot it again. That's the beauty of the digital darkroom. And then you can send the results to your friends as attachments to e-mail messages over the Internet so that they see them almost as quickly as you do.

Is Digital Imaging for You?

Though CCD imaging has made great strides over the past few years, it still trails conventional astrophotography in certain ways. Because of the great expense of very large chips,



The North America and Pelican nebulae in Cygnus imaged with a 4-inch apochromatic refractor at f/5 and an SBIG ST-8 camera. Robert Gendler most of those found in CCD cameras today are smaller than their film-based counterparts. A 35mm film frame measures 24 by 36 mm, for example, with common CCD chips such as the Kodak KAF–0400 measuring slightly less than 7 by 5 mm — there's quite a difference between the two.

The smaller imaging area means that with a given telescope, the amount of sky that can be grabbed in a single exposure is correspondingly less. This narrow field of view may come as a shock to imagers who are accustomed to using a 35mm camera. Large galaxies such as M33 in Triangulum, which fit comfortably into a 35mm film chip, may overflow the boundaries of a CCD chip using the same telescope. Full-disk lunar images, taken digitally, are uncommon because of this limitation.

Fortunately, digital cameras don't require large telescopes for impressive results. Surprisingly good lunar, planetary, and deep-sky images are possible using a 6-inch scope. Thus, a small short-focal-length instrument can partly compensate for the small size of the chip by yielding as wide a field as possible.

Certainly larger CCD arrays are on the horizon. Already, Kodak's KAF–1300 (21 by 16 mm) and KAF–1600 (14 by 9 mm) are showing up on the marketplace. These chips contain 1.3 million and 1.6 million pixels, respectively. Someday, chips such as the Kodak KAF–16800 will be incorporated into amateur CCD cameras; it contains 16.8 million pixels over an array 36.9 mm square. Without waiting for large, inexpensive chips, the CCD revolution has also spawned the creation of very good focal reducers, lenses that can be inserted near the camera to enlarge the field of view and allow shooting of larger objects.

Though the revolution is moving quickly, for the most part it has been limited to black-and-white imaging. Color CCD imaging is not as straightforward as conventional color film work. Unlike point-and-shoot color digital cameras that produce color images through interpolation, astronomical CCD cameras produce a monochromatic result. The only way to get a color CCD image is to shoot three separate exposures through red, green, and blue filters and combine them in a process called tricolor imaging. CCD manufacturers sell so-called color filter wheels that allow manual or electric rotation of the different filters. After shooting a red exposure, you simply rotate the filter wheel and shoot blue, and so on with green. Software then combines the three exposures to produce a color result.

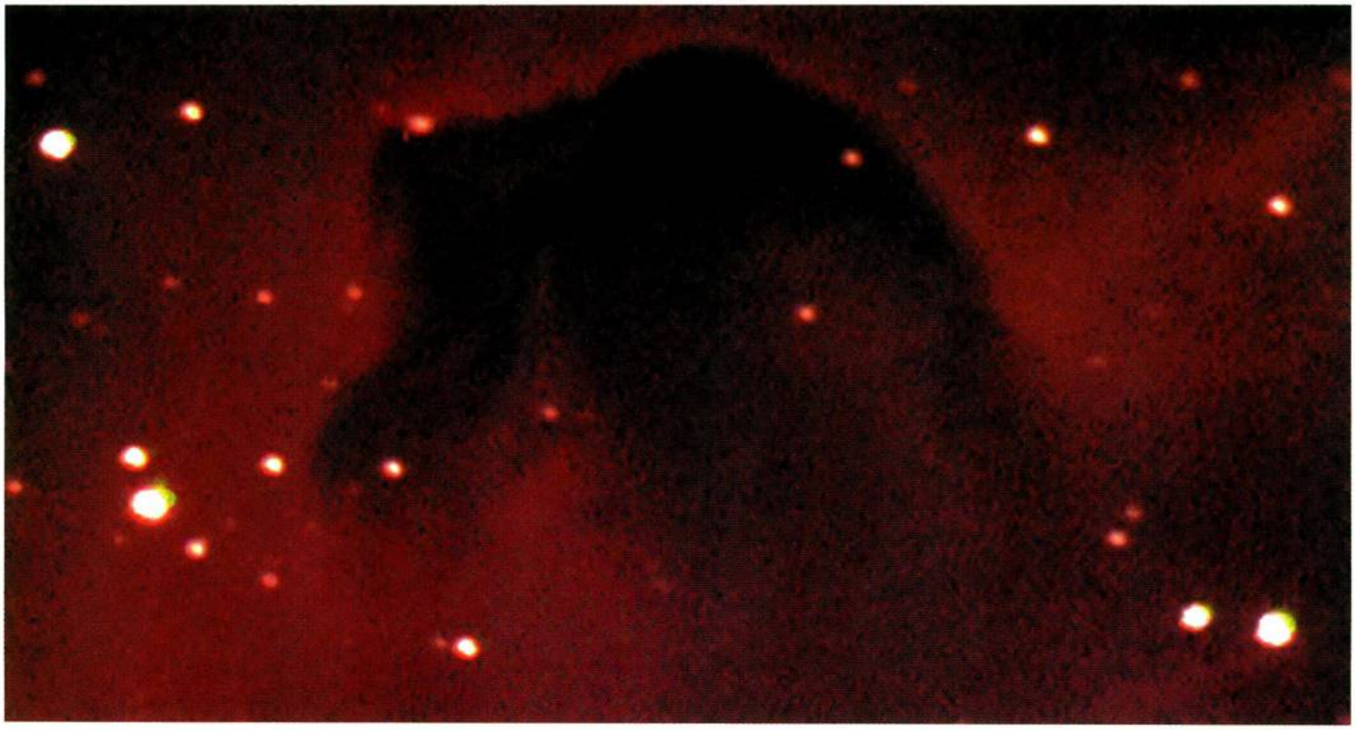
Tricolor imaging is capable of producing stunning images of nebulae, star clusters, and galaxies. Tricolor planetary imaging is even more challenging because the rotation of planets requires that the three exposures be taken quickly, within a few minutes of each other, so that features on the planetary surfaces don't change from shot to shot. Well-made tricolor planetary CCD images surpass the best results from conventional photography in sharpness and color saturation, and the techniques to achieve this will be covered in future articles.

Join the Revolution

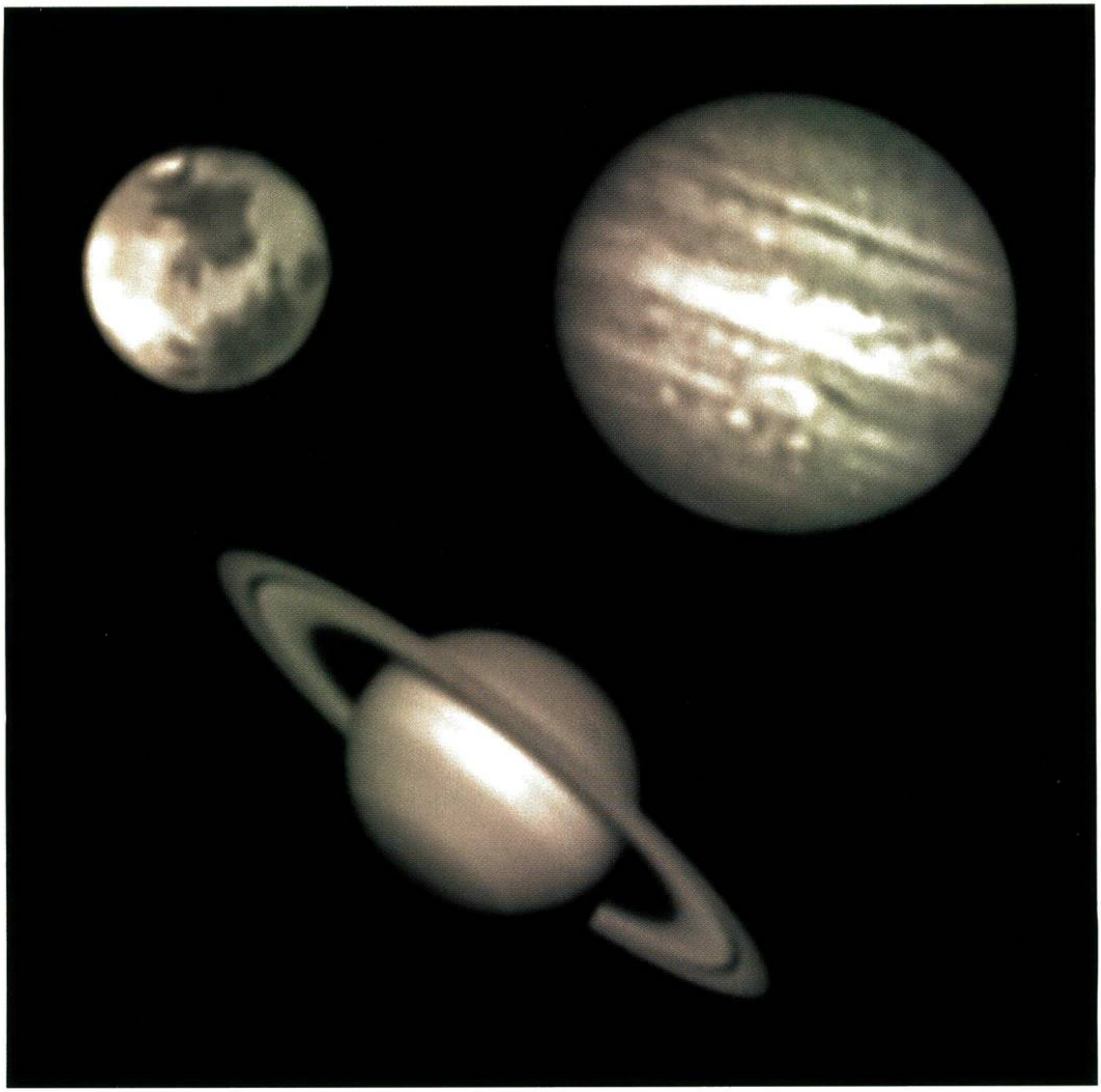
To start taking CCD images, you'll need a CCD camera, computer, and a telescope or optical system such as a telephoto lens to acquire the images. Many backyard CCD setups consist of an equatorially mounted Schmidt-Cassegrain telescope and a moderately priced CCD camera. Because few CCD cameras require a high-end computer to acquire images, many astroimagers pick up an inexpensive, used PC for astroimaging and use a separate, more powerful computer for image processing.

The basic software required for running the camera and doing basic image processing will come supplied with the camera. But to make the most of your images, you may want to invest in Adobe Photoshop or another graphics package such as Micrografix Picture Publisher, Maxim DL, or SuperFix.

Happily, unlike darkroom supplies, computer software does not degrade over time. Consider image processing software an investment in place of all the bottles of chemicals, an



Orion's distinctive Horsehead Nebula shot with a 25-inch reflector at f/5 and a Meade Pictor 1616XTE camera. Jack Newton



A mosaic of Mars, Jupiter, and Saturn shows the planets in 1997; it was shot with a 9-inch SCT and a Hi-SIS 22 camera. Thierry Legault

enlarger, and developing and printing supplies. Many image processing programs, particularly Photoshop, allow for incredibly powerful manipulation that only a handful of darkroom experts would have been capable of in the past.

Choosing a CCD camera is similar to selecting a telescope. Your decision will be partly based on whether you are more interested in planetary or deep-sky imaging. Larger CCD chips are better for faint objects, as they yield wider fields of view. Smaller CCD chips work reasonably well for planetary imaging because planets are very tiny in angular size, and so they don't require large arrays of pixels to image. Smaller pixel arrays also decrease the amount of time a fresh image takes to show up on-screen, and a short "shutter to screen" time helps with planetary imaging because many images might be taken in rapid succession to capture a few keepers, shot during moments of crisp seeing.

In the past, astroimagers had to be content with getting a few good deep-sky images per night. Each exposure had to be painstakingly hand-guided. CCD technology has changed all that. Digital cameras are highly efficient tools capable of capturing faint objects quickly and acting as automatic guiders. Now you, too, can capture the sky digitally. Though they have not yet supplanted film, CCD cameras have established a significant place for themselves in the future of backyard astronomy. A

Gregory Terrance is a longtime contributor to Astronomy. *This is the first of several articles that will cover digital imaging.*

Puppis

Bountiful star clusters join with a few bright planetary nebulae to make Puppis the Stern an observer's delight.

by **Tom Polakis**

THE WINTER SKY PRESENTS A multitude of brilliant stars, yet none commands our attention more than Sirius — the luminary of Canis Major and the brightest star in the sky. You can find Sirius easily using the familiar shape of Orion the Hunter: Simply draw an imaginary line through the three stars that form Orion's Belt and extend it to the southeast. If you continue that line for an equal distance past Sirius, you'll find yourself smack in the middle of this month's constellation — Puppis the Stern.

Puppis once combined with its neighbors Carina, Pyxis, and Vela to form the giant constellation Argo Navis, the Ship of the Argonauts. French astronomer Nicolas Louis de Lacaille divided this monster ship of the southern sky into four parts in the 18th century. Unfortunately, the southerly location of Puppis means Northern Hemisphere observers have only a narrow window in which to view the constellation, with the best times for evening viewing coming in February and March.

The plane of our Galaxy cuts through Puppis, endowing it with plenty of nearby star clusters and nebulae. The Milky Way's soft glow, particularly evident in the northern and eastern parts of the constellation, resolves into countless stars with the slightest optical aid. Unlike the clumpy structure seen in other directions, the Milky Way in Puppis appears as a uniformly wide and bright band, interrupted only by subtle, dark clouds of intervening dust.

Although Puppis contains nearly 50 stars brighter than magnitude 5.0, the star pattern appears somewhat jumbled. The brightest star — Naos, or Zeta (ζ) Puppis — is also the only one with a name. It shines at magnitude 2.25 from a distance of 1,400 light-years, giving it the luminosity of 20,000 suns. With a surface temperature approaching 50,000° C, this blue supergiant star ranks among the hottest stars visible to the naked eye. Be sure to contrast the icy color of Naos to the warmer hues of the 3rd-magnitude stars Sigma (σ) and Pi (π) Puppis to the west.

Just 4° northwest of Naos lies a large group of stars easily visible to the naked eye. In his *New General Catalogue of Nebulae and Clusters of Stars*, J. L. E. Dreyer described a scattered cluster of 20 stars ranging from magnitude 5 to 8 in a 40' field and cataloged it as **NGC 2451**. Telescopically, it appears as an impressive array of a dozen bright stars around a ruddy, 4th-magnitude centerpiece. Yet this stellar grouping is only masquerading as an open cluster — observations show the stars to be moving in widely different directions.

One of the more spectacular open clusters in the night sky resides just 1.5° to the southeast of this cluster impostor. On the best of nights, **NGC 2477** appears as a faint mist to the naked eye. A 6-inch telescope shows as many as 100 stars of similar brightness, all fainter than 9th magnitude, packed into a circular area 20' across. The central 5' is very crowded and almost defies resolution. Larger apertures yield even better views. In a 13-inch scope, more than 200 stars glimmer in a medium-power field. While the density of stars drops off outside the central 10', the cluster can still be traced to its full extent of nearly

Artwork at left from *The Glorious Constellations*, © 1991; Harry N. Abrams, Inc.

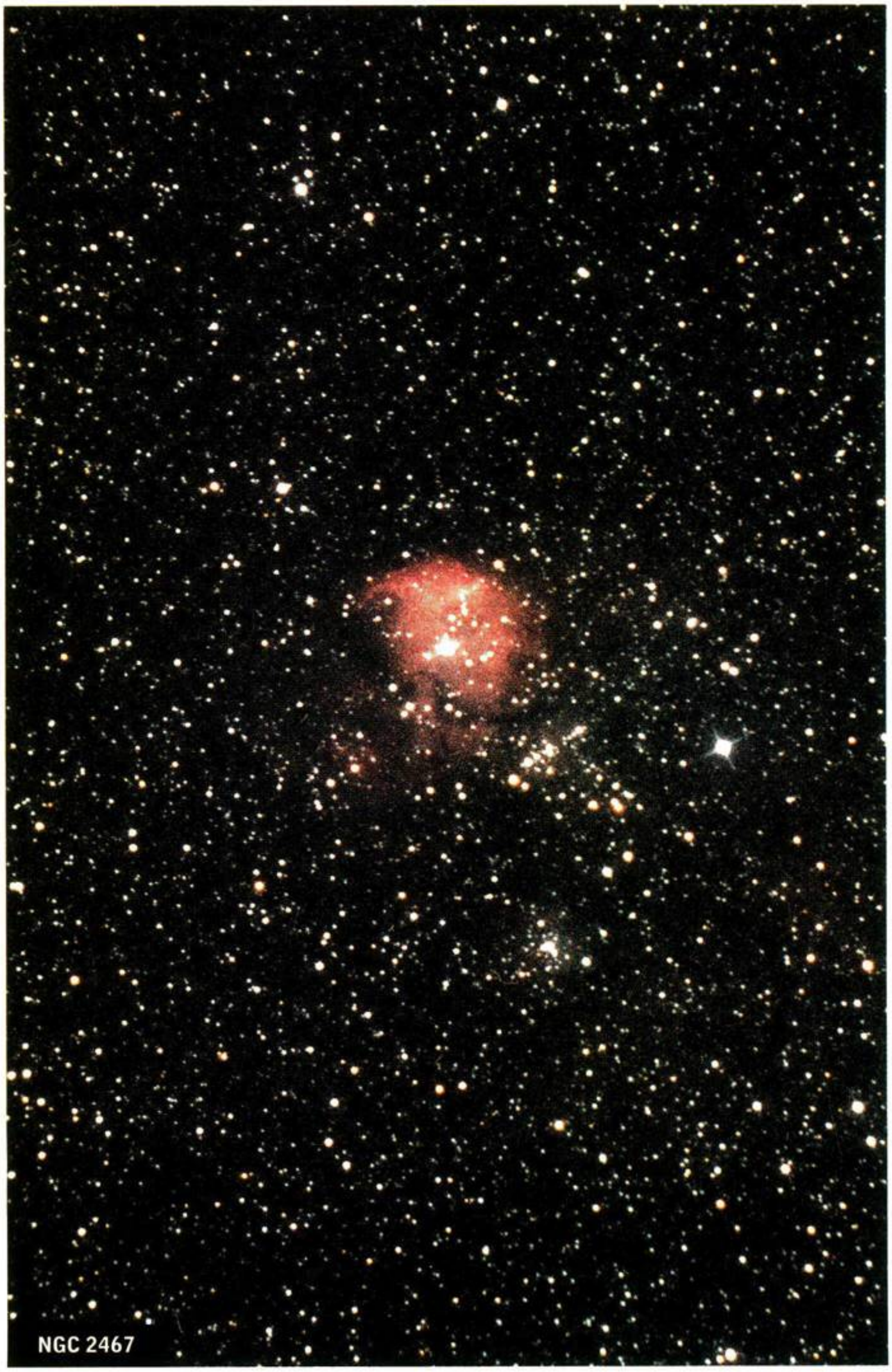
half a degree. NGC 2477 lies 4,300 light-years from Earth, much farther than the 4th-magnitude foreground star that lies just to its south.

Despite the numerous star clusters that populate Puppis, only one belongs to the globular variety. **NGC 2298** lies 20° due south of Sirius, below the hind legs of Canis Major. At a distance of between 30,000 and 40,000 light-years, this globular does not appear dazzling. Small telescopes show a broadly concentrated halo only 2' across and a graininess that suggests the presence of stars. A 10-inch scope at a dark site extends the halo's size to 3' and brings out a dozen or so of the cluster's brightest members.

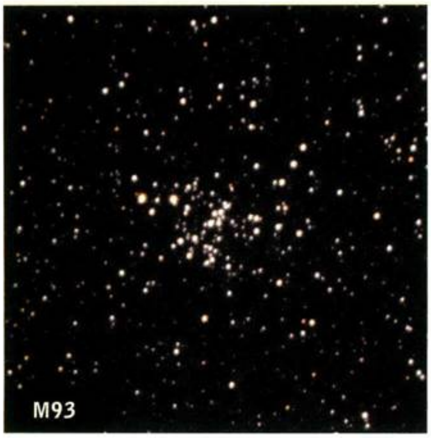
The easiest way to find the open cluster **NGC 2439** is to project a line from Delta (δ) through Eta (η) Canis Majoris and extend it about an equal distance. In a small telescope, you should see 15 stars forming a well-defined ring 4' across. R Puppis, a slightly variable star that hovers around magnitude 6.6, lies at the northeastern edge of the ring. An additional 20 fainter stars surround the ring and bring the cluster's apparent size up to 8'. On the best nights with a large scope, the much fainter cluster Ruprecht 30 can be seen as a light stellar dusting 20' to the northeast.

Scan 1.5° northwest of the 3rd-magnitude star Xi (ξ) Puppis and you'll come to the bright open cluster **M93** (NGC 2447). As with most of the open clusters included in the Messier catalog, this one can be glimpsed with the naked eye from a dark site. In a small telescope at 100x, M93 readily shows an embedded triangle of 30 bright stars spanning 5'. Because most of the cluster's stars glow brighter than 12th magnitude, larger apertures fail to add much to the view. Although it's hard to define the edge of a cluster among these rich starfields, the main body of M93 contains approximately 50 stars in an area 15' across.

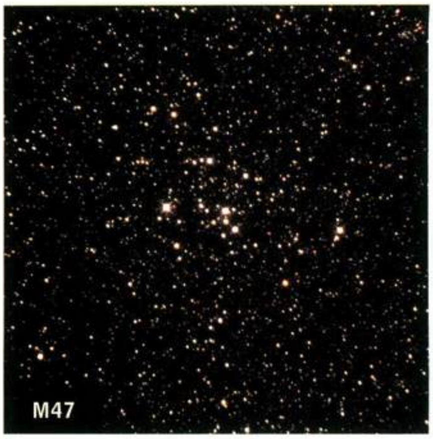
About an equal distance on the opposite side of Xi lies the open cluster **NGC 2467** and its associated nebula. The cluster spans 15' and appears as little more than a mild enhancement of a very rich Milky Way starfield. With a nebula filter, however, the emission nebula Sharpless 2-311 stands out spectacularly. Its high surface brightness invites high-magnification views. With a filter at 150x, the brightest clump measures 5' by 4' and looks like


NGC 2467

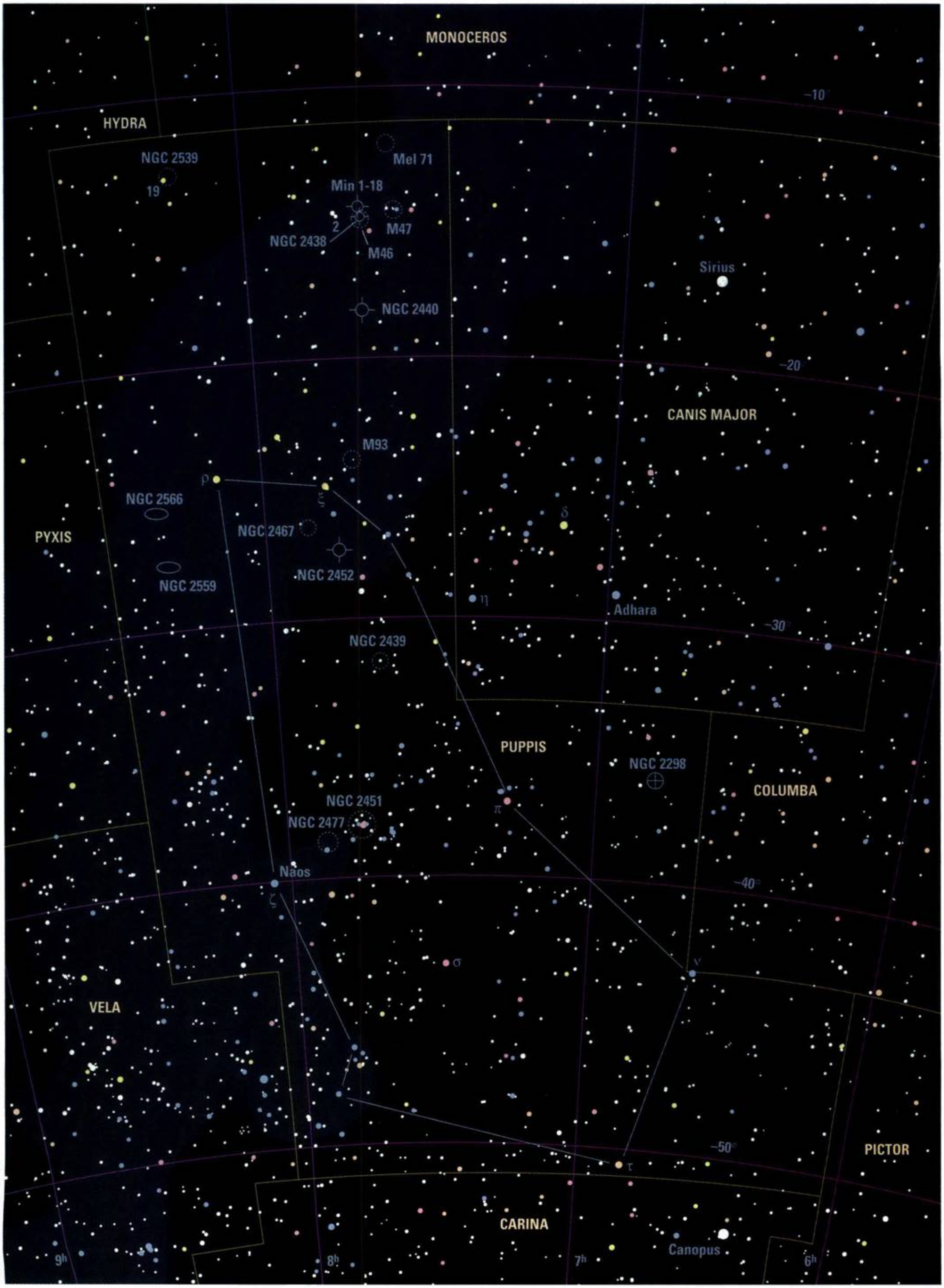
Steve Quirk


M93

Jack Newton


M47

Lee C. Coombs


MONOCEROS
−10°
HYDRA
NGC 2539
19
Mel 71
Min 1-18
2
NGC 2438
M47
M46
Sirius
NGC 2440
−20°
CANIS MAJOR
M93
ρ
ξ
NGC 2566
PYXIS
NGC 2467
δ
NGC 2452
NGC 2559
η
Adhara
−30°
NGC 2439
PUPPIS
NGC 2298
COLUMBA
NGC 2451
π
NGC 2477
Naos
ζ
−40°
σ
ν
VELA
−50°
PICTOR
τ
CARINA
Canopus
9h
8h
7h
6h

Astronomy: Elisabeth Rowan

a very large, mottled planetary nebula with a hollow center and a brighter southern rim. Backing off on the power brings into view a long strip of nebulosity to the northeast that extends 15' long and 5' wide.

Head 1.5° southwest of NGC 2467 and you'll come to **NGC 2452**, a small, bright planetary nebula formed when a sunlike star reached the end of its life and ejected its outer layers. High magnifications show an elongated disk that resolves into two tiny lobes, with the southern lobe brighter. The center of the disk looks dark, suggesting an annular structure. The open cluster NGC 2453 lies in the same telescopic field just 8' to the north. It contains about 15 very faint stars in an area 3' across. At a distance of some 19,000 light-years, the cluster lies about twice as far away as the planetary.

Most of Puppis sits inside the "Zone of Avoidance," the region in which light from distant galaxies gets blocked by intervening dust in the Milky Way. Yet the light of a few galaxies does manage to sneak through in places. One such spot lies 3° southeast of the 3rd-magnitude star Rho (ρ) Puppis, where you'll find the barred spiral galaxy **NGC 2566**. Through a 12-inch telescope it appears small and bright with little central concentration save for a faint stellar core. The elliptical galaxy IC 2311, located 7' to the north, looks a little brighter than NGC 2566 and shows a strong brightening toward its center.

In an extremely rich starfield just 2° south of this pair lies another barred spiral, **NGC 2559**. It appears 2' long and 1' wide, with the long axis oriented north-south. You should see a faint, broad concentration toward the galaxy's center. Both NGC 2559 and NGC 2566 belong to a recently recognized cluster of galaxies roughly 100 million light-years away. Known as the Puppis concentration, this is a rare example of a galaxy cluster seen through the disk of the Milky Way.

Some of the brightest and most interesting telescopic objects in Puppis — and the most accessible to Northern Hemisphere observers — lie near the constellation's northern boundary. The bright open cluster **M47** (NGC 2422) is an easy naked-eye target from a dark site. Although it shows great promise when viewed through binoculars or a finderscope, it's somewhat disappointing in a telescope. Ten stars that shine between 6th and 9th magnitude concentrate in the central 10' while another 40 stars fill the cluster's half-degree diameter. An 8th-magnitude orange star on the western edge contrasts nicely with the primarily white members of the cluster.

NGC 2477

Luke Dodd

The magnificent **M46** (NGC 2437) resides a little more than 1° east of M47. An 8-inch scope reveals more than 100 stars of similar brightness in a well-defined circle 25' across. The cluster's stars appear uniformly distributed over this area with the exception of a concentration at the southern edge separated from the central region by a starless gap.

Deep-Sky Objects in Puppis

Object	R. A. (2000.0)	Dec.	Mag.	Size/Sep	Type	Notes
NGC 2298	6h49.0m	–36°00'	9.2	6.8'	GC	
M47 (NGC 2422)	7h36.6m	–14°30'	4.4	29'	OC	
Melotte 71	7h37.5m	–12°04'	7.1	9'	OC	
NGC 2439	7h40.8m	–31°39'	6.9	10'	OC	
M46 (NGC 2437)	7h41.8m	–14°49'	6.1	27'	OC	
NGC 2438	7h41.8m	–14°44'	11.0	66"	PN	
NGC 2440	7h41.9m	–18°13'	9.4	14"	PN	
Minkowski 1-18	7h42.1m	–14°21'	15.0	32"	PN	
M93 (NGC 2447)	7h44.6m	–23°52'	6.2	22'	OC	
NGC 2451	7h45.4m	–37°58'	2.8	45'	OC	
2 Puppis	7h45.5m	–14°41'	6.1/6.8	17"	Dbl	
NGC 2452	7h47.4m	–27°20'	12.0	19"	PN	
NGC 2477	7h52.3m	–38°33'	5.8	27'	OC	
NGC 2467	7h52.6m	–26°23'	7.1	14'	OC	with nebula Sharpless 2-311
NGC 2539	8h10.7m	–12°50'	6.5	21'	OC	
NGC 2559	8h17.1m	–27°28'	10.9	4.2' by 2.3'	Gal	SB(s)bc
NGC 2566	8h18.7m	–25°29'	11.0	4.1' by 2.0'	Gal	SB(rs)b

Object: Designation in Messier, NGC, or other catalog. **R.A. (2000.0) and Dec.:** Right ascension and declination in epoch 2000.0 coordinates. **Mag.:** Visual magnitude. **Size/Sep:** Size in arcminutes or arcseconds, separation in arcseconds. **Notes:** Hubble type for galaxies.

The Stern

"To waft the heroic progeny of Greece;
When the first Ship sailed for the Golden Fleece —
ARGO — exalted for that daring feat
To fix in heaven her shape distinct with stars."
Memorials of a Tour on the Continent, 1820
William Wordsworth (1770–1850)

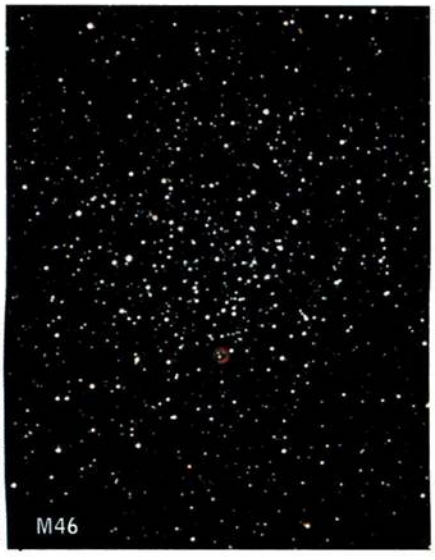
Puppis is best known as the stern of the great ship Argo, which carried Jason and the Argonauts on their search for the Golden Fleece (see "Vela and Carina," April 1999). But the Egyptians also saw a great ship in the constellations of Puppis, Vela, and Carina. It is the ship of the dead, the ship that carried Isis and Osiris to safety during the great flood.

Like all good myths, the tale centers on jealousy, power, and greed. The union of Geb (the earth-god) and his wife, Nut (the sky-god), produced two couples: Osiris and Isis, and Seth and Nephthys. Before moving to the kingdom of the blessed, Geb transferred his earthly powers to Osiris. Osiris, with the help of his sister/wife, Isis, ruled Egypt gracefully. He took humanity's welfare to heart and spread the knowledge of agriculture and art. Egypt was peaceful and prosperous, but not for long.

Seth was jealous of his brother's success and power. So he invited Osiris to a feast and tricked him into a chest. Seth ordered that the chest be cast into the river. Informed of the treachery, Isis initiated a massive search for her entombed husband. She found the chest in Byblos in Phoenicia and brought it back to Egypt. Unfortunately, Seth managed to get Osiris's body and immediately had it cut into 14 pieces, which he scattered throughout the land. But Isis didn't give up easily. She found the pieces and put them back together. With the help of Nephthys and other deities, she created the first mummy.

The story of Osiris evokes the cycle of nature in Egypt. Each year, as the Nile floods, the land is renewed. Osiris died, was immersed in the Nile's waters, and was then resurrected. He represents a buried seed that is reborn as a shoot months later. — *Andrea Gianopoulos*

What makes M46 even more special is the presence of the planetary nebula **NGC 2438** among its stars. The planetary's 1'-diameter disk stands out beautifully against the surrounding stars on the northern edge of the cluster. Use high magnifications to see the subtle ring structure. You may notice several stars within the ring, but none is the planetary's central star, an 18th-magnitude white dwarf beyond the reach of all but the largest backyard scopes. Although most sources indicate that the nebula lies significantly closer to Earth than the cluster does, recent radial velocity measurements suggest that it may belong to the cluster after all, with both at a distance of about 5,000 light-years.



B. Frank Hinson and J. Steve Foster

Pan 23' north of NGC 2438 to bring into view a much fainter planetary nebula, **Minkowski 1-18**. In a 16-inch telescope, it appears as no more than a pale gray disk 20" across. Experienced observers may be able to glimpse it in apertures as small as 13 inches.

A degree east of M46 lies the wide double star **2 Puppis**. The whitish 6th-magnitude primary star has a similarly colored and slightly fainter companion located a bit to the north-northwest. The pair can be split easily in any telescope at 50x.

Shift a little more than 3° south of M46 to locate **NGC 2440**, a bright planetary nebula some 3,500 light-years from Earth. A relative newcomer with an age of less than 5,000 years, this planetary sports a very hot central star with a temperature of nearly 200,000° C, making it one of the hottest stars known. A small telescope shows NGC 2440 as an oval disk about 25" long. Larger telescopes extend the perceived size and begin to resolve two lobes, with the northeastern one appearing brighter. A faint haze surrounds the bright inner disk that is centered on the 19th-magnitude central star.

Despite its obscure designation, **Melotte 71** ranks as one of the showpiece clusters in Puppis. Look for it 2.5° north of M47, just 1° south of the constellation's border with Monoceros. In a 10-inch telescope, Melotte 71 shows up as a well-defined group of 30 stars 10th magnitude and fainter that spans 6'. The star count doubles in a 16-inch telescope.

Our tour of Puppis ends 8° east of Melotte 71 at the open cluster **NGC 2539**. A small telescope shows 75 stars between 9th and 13th magnitude spread over a 15' diameter, while a 10-inch scope reveals more than 100 stars covering nearly half a degree. The brightest stars appear clumped in an oval that stretches east-west. Also note the 5th-magnitude yellow star 19 Puppis just off the southeastern edge of the cluster. As with many of the Puppis clusters, locating where this one ends and the rich starfields begin can be a challenge — but it's a challenge that most backyard observers relish.

Tom Polakis is an aerospace engineer who lives in Tempe, Arizona. His favorite astronomical pursuits are deep-sky observing and photography.

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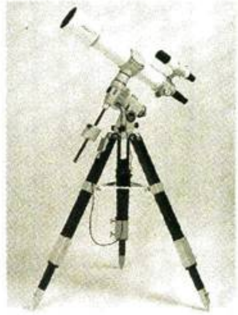
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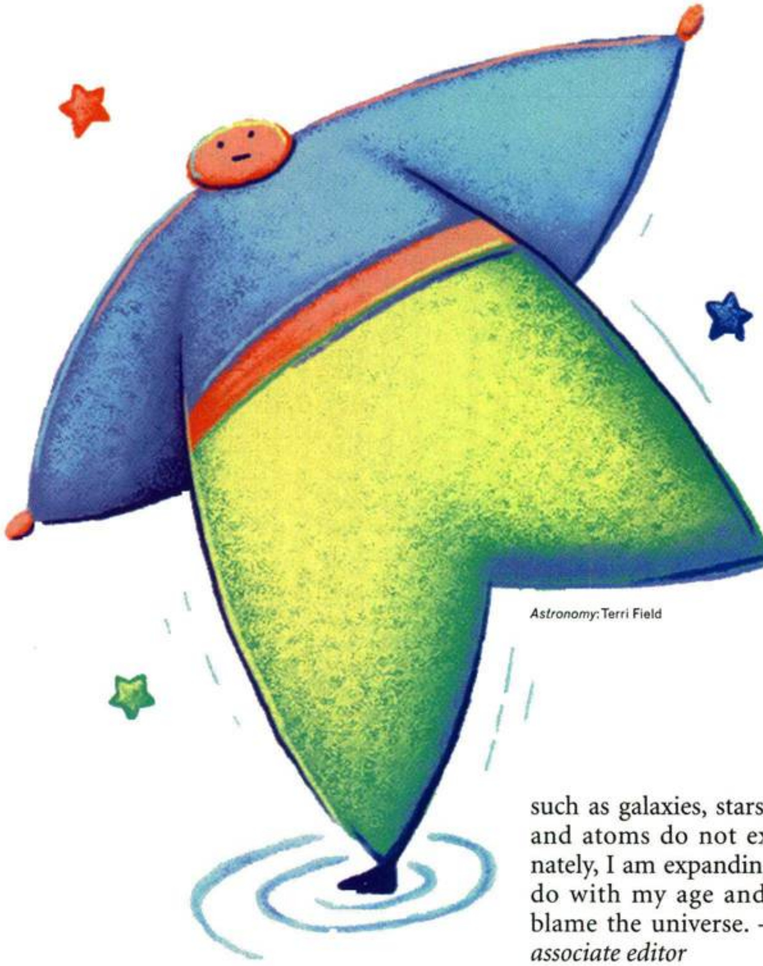
Expanding Universe, Entropy, Impact Craters, The Pleiades



Astronomy: Terri Field

Q: If the universe is expanding, would the space between atoms be expanding? Am I expanding? — *Tom Becker, South Windsor, Connecticut, and David Casler, Defiance, Ohio*

A: Fortunately, you're not expanding, and neither is the space between the atoms in your body. For this, we can thank the force of gravity. If an object has enough mass concentrated in an area so that gravity holds it together, gravity overwhelms the universe's expansionist tendencies. So objects such as galaxies, stars, planets, people, and atoms do not expand. Unfortunately, I am expanding, but that has to do with my age and diet, so I can't blame the universe. — *Robert Naeye, associate editor*

Q: I've learned that the universe becomes more and more disordered as time goes on, a process known as entropy. And yet, since the Big Bang, the universe has organized itself into more organized structures, such as galaxies, stars, planets, and life. How can the universe be getting more ordered when entropy is universally increasing? — *Mark Mumaugh, Cheyenne, Wyoming*

A: This question nicely illustrates what the law of increasing entropy actually means. Entropy measures the degree of disorder in any substance or system; the law of increasing entropy is thus the tendency for physical systems to evolve toward more disorganized conditions. According to the laws of physics, the total entropy of the universe (or any isolated physical system) always increases. Smaller components within the universe can decrease their entropy, however, as long as other parts of the universe experience an even greater entropy increase so that the total entropy of the whole universe increases.

When a star burns hydrogen into helium nuclei, for example, the nuclei become more ordered and their entropy decreases. The nuclear fusion process that enforces this order also produces prodigious quantities of radiation that ultimately stream out from the star's surface. The entropy carried by this radiation greatly exceeds the entropy lost by the nuclei in the core. As a result, the total entropy of the system increases, even though the entropy of one part of the star (the nuclei) decreases.

This same general theme applies as the universe organizes itself into galaxies, stars, planets, and life. For each act of organization, the entropy of other constituents of the universe always increases enough to compensate, and the total entropy of the universe increases.

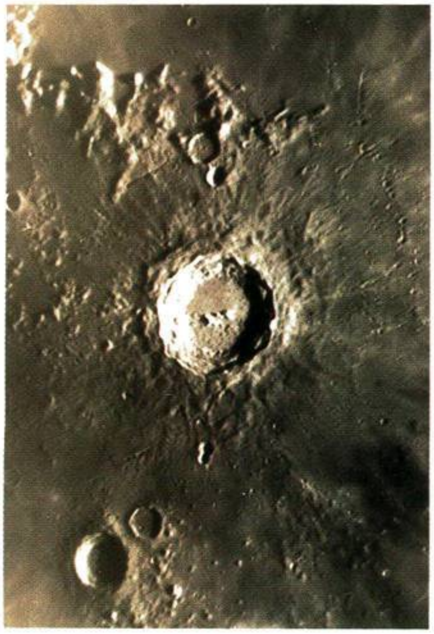
Some critics of Darwinian evolution have invoked the law of increasing entropy to argue that biological evolution could not take place. Because biological organisms are clearly "ordered," how could they ever arise if all systems are supposed to evolve toward states of increasing disorder? The resolution is simple: The biosphere of Earth is not a closed system. If the entropy within the biosphere decreases, then the entropy of other parts of the system must increase even more to "pay for it." In this case, the biosphere is powered by radiative energy from the sun, so the entropy of the entire sun/Earth/biosphere system must be considered. When the proper accounting is done, the total entropy of the whole system increases, as it should according to physical law. — *Fred Adams, University of Michigan, coauthor of* The Five Ages of the Universe *(The Free Press, 1999)*

Q: Can one calculate the speed and mass of a projectile that made an impact crater if the diameter of the crater and the height of the crater wall is known? — *Tjaart van der Walt, De Aar, South Africa, and Clay Reid, Leigh Creek, Australia*

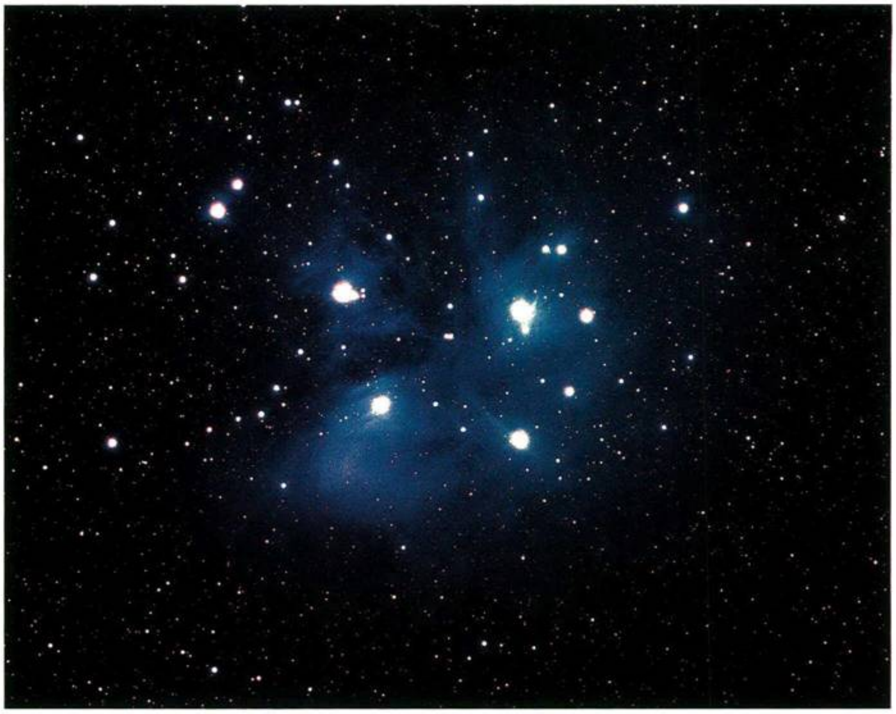
A: Like many simple questions, this one does not have a simple answer. The size of the crater produced by a given projectile depends on many factors: the size, density, and speed of the projectile, the angle at which it strikes, and the composition, gravity, and density of the planet it strikes. The size of the final crater is thus not enough to independently determine the size, speed, and impact angle of the projectile. The height of the crater wall seems to be a function of the crater diameter and is thus not an independent piece of information.

That said, professional researchers in the field of impact cratering commonly (perhaps more often than most of them would admit!) use the crude rule of thumb that the diameter of an impact crater is about 10 times larger than the projectile's diameter. The projectile speed cannot be computed from the crater diameter, and so it is taken to be close to the average for either asteroidal or cometary impacts. These speeds are about 45,000 miles per hour (72,000 kilometers per hour) on Earth for asteroid impacts and about 110,000 miles per hour (180,000 km per hour) for cometary impacts.

If you would like to input your own numbers, you will find a small program on my website that uses the methods of my book (*Impact Cratering*, Oxford University Press, 1989) to relate projectile properties to the crater diameter just after impact (larger craters often undergo a second stage of collapse that makes them even bigger). This can be found at www.lpl.arizona.edu/tekton/crater.html. — *Jay Melosh, University of Arizona*



An asteroid about 2.5 miles (4 km) across or a comet about 2 miles (3.5 km) across excavated the 55-mile-wide (90 km) impact crater Copernicus on the moon. It would take a slightly larger projectile to create the same size crater on Earth. Giorgio Mengoli



They sure are pretty, but the stars of the Pleiades don't encompass a large enough area of sky to be considered an official constellation. George Greaney

Q: According to *Webster's Dictionary*, a constellation is a "configuration of stars." So why is the Pleiades (M45) not considered a constellation? — *Liem Hoang, Seattle, Washington*

A: Simply put, the stars of the Pleiades (Messier object 45) don't encompass a large enough area of sky to be considered a constellation. Instead, astronomers consider the Pleiades to be an open star cluster.

It is true that a constellation is defined as a pattern of stars in the sky. The International Astronomical Union (IAU) has officially divided the sky into 88 regions, each of which surrounds a different constellation. The rectilinear subdivisions are similar to states. Such divisions enable astronomers to pinpoint the location of deep-sky objects. Thus, I can tell you that M44 (the Beehive star cluster) is in Cancer, just as I can tell you that Disney World is in Florida.

The IAU probably didn't choose to officially designate M45 as a "constellation" because it was already designated as a Messier object. More importantly, the Pleiades doesn't encompass a large enough angular size to serve well as one of the IAU's subdivisions. The Pleiades subtends an angle of about 1.5°. Triangulum is one of the smallest constellations, yet it spans about 10° in its shortest dimension. — *Edward Gleason, Southworth Planetarium, Portland, Maine*

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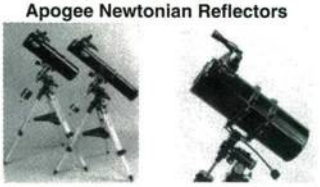

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New Meade ETX-90/EC-with pushbutton electronic control comes standard with dual-axis drive system W/4 dual axis speeds. Add the Meade Autostar hand control to your scope and get fully automatic go to capability to over 12,000 objects. Available Now. $595. Original ETX-90 RA $495.

Meade Model DS-114EC 114MM(4.5") 910MM F/8 Newtonian system. Complete W/6x30 finder, full-length tripod.
Meade Model DS-114EC-114MM(4.5") Newtonian reflector 910MM focal length F/8, #492 Dual electronic control system $399.
#495 Autostar Computer Controller $99., Also available: DS 127EC (5") 1020MM F/8.

ACCESSORIES FOR ETX-90 RA, EC, 125EC

#126 Barlow	$47.95
#64 T-Adapter	$34.95
#932 Image Erect Diagonal	$49.95
Hard Case for 90	$99.95
Soft Case for 90 RA & EC	$39.00
07329 #775 Hard Case for ETX-125EC	$155.00
8X25 right Angle Finder for 90	$49.95
Auto Star Hand Control for 90 &125 EC	$149.00
Equatorial Table Top Tripod (w/Hi Lat Leg)	$29.95
Equatorial Table Top Tripod (w/Hi Lat Leg) for 125 EC	$55.00
Deluxe Field Tripod	$199.00
07077#1244 El. Focus for all ETX-90's	$119.95
07078 #1247 Elect. Focuser-ETX-125EC/S.scope	$119.95

DS SERIES ACCESSORIES

07437 #495 Autostar (hand box only)	$99.
07438 #492 Dual Motor Elect. Control System	$129.
07439 #493 Autostar, Complete System	$199.
07076 #1240 Elect. Focuser	$75.
07041 #490 Elect. Focuser	$75.
07221 #937 2" Diagonal Mirror w/.96 & 1.25" Ad	$45.
Meade 8" LX-10	**$995.**
Super Wedge	$395.
New Field Derotator for 8", 10",and 12" SCT's, and 7" Maksutov	$395.
Magellan I	
#2010 for all Meade Dobsonians	$295.
#2011 for DC Starfinders-6"-8"-10"	$295.
#2014 for LX-10	$375.
Magellan II	
#2018 for DC Equatorial Starfinders-6"8"10"	$495.
#2024 for LX-50	$495.
3000 Series Plossls 5,6.7,9.5,16,25MM	$49.95
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NEW Meade Series 4000 8MM to 24MM Zoom Eyepiece $219.95

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- Optec Focal Reducers
- Homeyer Flip Mirrors
- Parallax Mounts & Accessories
- Rainbow Optics Star Spectroscope
- We stock Schuler CCB Filters
- Brandon/Questar eyepieces

NEW ETX DEW SHIELD

Fits all of the Meade ETX models. The Dew Shield is installed by sliding it over the ETX tube, extend the shield when needed for dew and retract when not in use. It also serves as a lens shade. **$35.00**

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7x50 and 10x70 have eye relief of 23MM. 16x70 has eye relief of 12.4MM.

Tripod Adapter Bracket	$18.00
(Available for immediate shipment)	
Heavy Duty Virgo Bino Mounting Bracket	$25.00

We also carry and stock Zeiss, Swarovski, Swift, Nikon, Pentax, B&L, Steiner, Minolta and Kowa spotting scopes.

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We stock the entire JMI line-SPECIALS

MotoFocus for LX5/6/200	$95.00
Moto Decs--for all Meade SCTs	$85.00
C-8 Moto Dec	$85.00

SCT Owners; avoid image shift--
NGF-S Focuser w/MotoFocus.......$249.00
Wheeley Bars for all Scopes: $155.
For Meade/Celestron SCT's w/Levelers...$145.00
Also Available for Meade 12"/Celestron 11" CALL

NEW ACCESSORIES FOR ETX:

Wedge w/Levelers	$115.00
Tripod	$115.00
MotoFocus/MotoDec Combo w/hand control	$165.00
New Piggyback Bracket for ETX	$48.00
New Hard Case for ETX	$99.00

APOGEE 80mm ED-*Best Buy!*

AP-80ED 80mm f/6.25 (500mm) Refractor using ED Glass, Comes with MgF2 Coated Optics, 2" HD Crayford Focuser with focus lock for photography, 2" to 1.25" adapter, 1.25" 45 degree Erecting prism, 1.25" 25mm Plossl eyepiece, tripod adapter (1/4"-20) and carry case. **$699.00**

LOSMANDY GM8 Mount

Complete System Package

Dual Axis, PEC DRIVE, North-South operation.Three photo guide rates. Auto guider ready. Four tracking rates.

Adapter Plate. (Specify Telescope) 7 lb. counterweight. Weight capacity--30 lbs
The GM-8 is perfectly suited for the following telescopes--Astro Physics 4" Traveler, Astro Physics 5" F-8, Celestron C-5, C-8, C-9, 25SCT,Celestron 102 Refractor, Caravolo HD-145, Meade 8" and 10" SCT, Meade 4" and 5" APO, Tele Vue Pronto and Genesis and new Meade 7" Maksutov.
Get a FREE Waterproof, Seal Proof Case for GM8 Eq. Head

New Price:$1449.00 Includes Shipping
$99 Polar Finder w/Mount - Free Case

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FREE Polar Finder w/Mount

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- 9000 + objects includes Messier, NGC., planets and add up to 59 of your favorites. Epoch 2000 coordinates.
- Liquid crystal display, backlit, heated.
- Rs-232 Serial Port

Complete module with encoders and mounting hardware.......$595.00

TELRAD w/Base
$39.00

Batteries included!

Hinged Deluxe Dew Caps	$10.00
Extra Bases	$ 7.95
Extra Reticles	$ 2.95
Pulsar Unit	$19.95

SUPER EASY VIEW Eyepieces by Apogee

Back by Popular Demand
Recommended by Dr. Donald Parker

3.6MM	$125.00
5.5MM	$125.00
9.5MM	$125.00
Set of three	$350.00

RIGEL SYSTEMS

Starlite Dual LED Flashlight	$22.00
NEW Skylite: Dual Color LED Flashlight	$29.95
Quick Finder-New Version	$35.00

New Polymer Plus Solar Filters by THOUSAND OAKS OPTICAL

Available in all sizes, Full Aperture, Off Axis and also available for camera lenses. Unsurpassed sharpness. Contact us for details

NEW NEBULA FILTERS
Type LP-1 Broad Band, Type LP-3 Oxygen, Type LP-2 Narrow Band, Type LP-4 Hydrogen. Available for 1.25"& 2" eyepieces. From $89.00

COMPUTER SOFTWARE

"THE SKY" by Software Bisque

CCD Soft	$719.00
Starry Night Deluxe	$89.95
Star Chart 3	$39.95

The Sky, Level 4 Version 5 Now Available.
Max DL Imaging Software..$365.00

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7x50 Right Angle Finder	$109.95

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Celestron Nexstar 5

CELESTRON Counter-punches with its entry into the mid-size computer-driven telescope market. The Celestron **Nexstar 5** combines time-proven Celestron 5" Schmidt-Cassegrain optics, a single metal fork arm and smooth drive system to make an excellent visual and photographic telescope. The built-in computer has 18,473 objects. Celestron's Nexstar 5 is ready out of the box to run from AA batteries or AC current.

The Nextar 5 is a fine value at $1,199.

Other Celestron Telescopes at Lumicon

Ultima 2000	$2699
Celestar Deluxe	$1699
Celestar	$1099
CM 1100– 11" SCT	$3399
Starhopper 8" Dob	$429
Starhopper 6" Dob	$339
C102-HD 4" Refractor	$499
FS114 Deluxe	$299
G-150 6" f/8 Refractor (NEW)	$1199

Lots of Adapters

2" adapter for C-8 Meade 2080, etc.	$29.50
2" adapter for C-80, C-102 refractor	$39.50
2" adapter for C-70, C-80F, C-102F fluorite	$39.50
2" adapter for C-6, Comet Catcher, Meade 395	$30.00

Extension Tubes

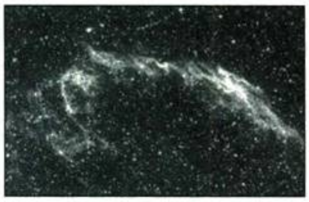
1" long $1^{1/4}$" OD thread-in extension	$12.00
$2^{1/2}$" long extension (holds $1^{1/4}$" filters)	$19.50
$4^{1/2}$" long extension for $1^{1/4}$" eyepieces	$29.00
3" long extension for 2" eyepieces*	$29.00
2" long extension for 2" eyepieces*	$29.00

Viewing Adapters

2"\1 *$^{1/4}$" reducing bushing, thread 48mm**	$25.00
2" T-thread adapter, threaded 48mm*	$25.00
T-thread $1^{1/4}$" adapter	$25.00
F/10 2" or $1^{1/4}$" eyepiece viewing adapter for Giant Easy-Guider	$59.50
Low profile star diagonal eyepiece holder	$16.00
Meade 2" diagonal /Giant Easy-Guider	$39.50

**threaded to hold 48mm filters*

LUMICON FILTERS - BEST IN THE WORLD



AMAZING O-III FILTER™

"The LUMICON O-III proved to be our favorite . . .it gave the greatest contrast gain."
ASTRONOMY, February 1991

Greatly Enhanced Detail

"Consistently performed well on all emission and planetary nebulae. Detail and structure were greatly enhanced in more than two dozen objects I viewed." *SKY & TELESCOPE, July 1995*

Better than a Dark Sky Site?

"From my light-polluted backyard, the view was better with my O-III than with any other filter tested. The view was even better than without the filter from a dark-sky site."
SKY & TELESCOPE, July 1995

See The Horsehead!

"LUMICON's H-Beta Filter will show subtle features in emission nebulae that others fail to reveal. It can't be beat for the elusive Horsehead and California Nebulae." *SKY & TELESCOPE, July 1995*

Deep-Sky Filter™
BEST for Astrophotography!

"Stunning is all I can say," says noted astrophotographer Jack Newton. Great for both color and black and white photography.

Best Wide-Band Filter!

"Based on our tests, we'd recommend a LUMICON Deep-Sky and Oxygen III as complementary filters. The LUMICON Deep-Sky Filter clearly had the best contrast for reflection nebulae."
ASTRONOMY, February 1991

LUMICON Multiple Filter Selector, holds 5 $1^{1/4}$" filters .... $129; $99 if ordered w/filter
$1^{1/4}$" LUMICON DEEP SKY Filter threads into most $1^{1/4}$" eyepieces $99.50
48mm LUMICON DEEP-SKY Filter threads into most 2" eyepieces.
Also fits EASY-GUIDERS $199.50
2" LUMICON DEEP-SKY Filter threads into most 2" eyepieces. Also has male & female camera T-threads for prime focus photography $199.50
72mm LUMICON Giant DEEP-SKY Filter
(62, 67, 77mm adapter, $10, 82mm $16) $399.50
2" Rear Cell Filter, fits SCT's............Deep-sky, $199.50 UHC,O-III, H-Beta $199.50
$1^{1/4}$" LUMICON UHC Filter threads into most $1^{1/4}$" eyepieces $99.50
48mm LUMICON UHC filter fits most 2" eyepieces $199.50
Choice of any two LUMICON filters (save 7%) .... $1^{1/4}$" $185.00..............48mm $370.00
LUMICON H-Beta Line Filter (9mm bandpass at 486nm) for the California Nebula, Horsehead Nebula ,and other extremely faint nebula. .... $1^{1/4}$" $99.50 .... 48mm $199.50
Oxygen-III Filter for very faint planetary and defuse nebula, 11nm bandpass at 496nm and 501nm O-III lines. ....$1^{1/4}$" $99.50 .... 48mm $199.50
Lumicon Comet (Swan Band) FIlter..........$1^{1/4}$" $99.50 .... 48mm $199.50
Universal Adapters for $1^{1/4}$" filters. Adapts the filters to any $1^{1/4}$" eyepiece $19.50
Universal Adapter for 48mm or 2" filters. Allows use of any $1^{1/4}$" eyepiece $25.00

SKY VECTOR™ $299!!!
Includes Computer, Encoders, Hardware

LUMICON Sky Vector Features:

- "GUIDE" mode leads you to object
- Digital right ascension readout to 1 min.
- Digital declination reading to 10 arc/min.
- 4000 pulse (0.09 accuracy) encoders
- Polar Alignment NOT REQUIRED!
- Motor drive NOT REQUIRED!
- Just two stars to align
- Works Equally well for alt-azimuth telescopes like Coulter Odyssey and equatorial mounts like C-8, Meade 2080.
- No need to enter latitude, longitude etc.

SKY VECTOR I™ **$299.00**
NEW! With over 220 object memory including the 110 Messier and 58 best NGC objects.

SKY VECTOR Ii™ **$349.00**
Over 3600 objects! Also included planets and full visual descriptions.

NGC-SKY VECTOR™ $439.00
12,000 objects! PC serial port NGC Sky Vector with IDENTIFY (Sky Tour) mode; 12,000 object memory including the corrected RNGC catalogue, IC catalogue, P&K planetary catalogue and much more.

NGC-Sky Vector™
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MODE
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UP
DOWN
LUMICON®

Specify Telescope Type: Meade 4",8", 10",12" SCT, C-8, C-11, Odyssey 8", 10", 12", $17^{1/2}$" alt-azimuth; Meade 6"-16" Dobsonian. Ultima 8", $9^{1/4}$", 11" add $25.
C-14 add $75.

Tele-Vue Products

4X Powermate for 2" eyepieces	$265
5X Powermate boosts magnification 5x	$168
Ranger 70mm f6.8 apchromat w/45° diag.	$685
Pronto 70mmf6.8 w/45° erecting prism	$925
Tele-Vue 85,85mm f/7 APO telescope	$1995
Bino-Vue binocular w/2x correc.	$1030
Gibraltar mount with ash wood tripod	$530
8,11,15mm Plossl . $82 — **20,25mm**	$95
32mm Plossl, widest true field in $1^{1/4}$"	$110
55mm Plossl, widest possible field	$230
2.0x or 3.0x Tele Vue Barlow Lens	$105
2" Giant Barlow – 2x	$168
4.8mm Nagler 82° field, $1^{1/4}$" eyepiece	$175
7mm Nagler, $1^{1/4}$" eyepiece, 82° field	$220
9mm Nagler, 82° field $1^{1/4}$" or 2"	$240
12mm Nagler Type 4, 82° $1^{1/4}$" or 2"	$340
16mm Nagler Type II, 82° $1^{1/4}$" or 2"	$310
17mm Nagler Type 4, 82° $1^{1/4}$" or 2"	$370
22mm Nagler Type 4, 82° 2" only	$445
31mm Nagler Type 5, 82° 2" only	$595
2" Paracorr visual coma corrector	$235
3,4,6,8,10,14mm Radian,60° field	$228
15mm Panoptic $1^{1/4}$", 68° field	$210
19mm Panoptic $1^{1/4}$", 68° field	$240
22mm Panoptic $1^{1/4}$"/2", 68° field	$280
27mm Panoptic 2", 68° field	$330
35mm Panoptic 2", 68° field	$365

Note: TeleVue warranty may not be valid outside USA

LUMICON® binocular viewer

The new LUMICON Binocular viewer is judged to be equal or superior to even more expensive binoviewers. Custom made for Lumicon, these exquisite German-made units have the highest image transmission (91%) Threaded for filters. Both planetary and deep-sky viewers will be impressed. **$749.^{00}**

3X apochromatic relay lens
for Newtonians .... **85.^{00}**

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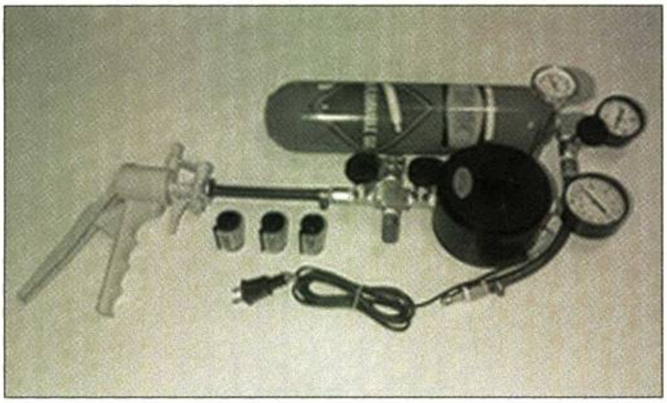


The **LUMICON MODEL 300 HYPER KIT™** Now on sale through the end of February 2000.

Any serious astrophotographer knows you cannot live without hypersentized photographic film that helps maximize the light collecting ability for prize astrophotos. For a limited time* you can own the **LUMICON MODEL 300 HYPER KIT** at the special discount price of just $265 - a $65 savings.
For just $265 you get:

- Lumicon model 300 Hyper Kit chamber with 110v heater and brass gauge
- Forming gas cylinder filled with 35 litres of forming gas (approximately 30 batches worth)
- High quality hand vacuum pump
- Stainless steel photo thermometer
- Auto load reel and 3 empty 35mm cassettes
- Complete instructions
- Gas refill $45

*while supply lasts

Meade's New 'Table Top' Scopes

Meade instruments now has two choices in the table top computer controlled scope category. Maksutov optics deliver sharp, high-contrast views in both the 90mm and 125mm sizes. The optional Autostar computer creates an excellent astronmy classroom on a tabletop.

ETX 90	**$595**
ETX 125	**$895**
Autostar (14,487 objects)	**$149.95**

MEADE®Equatorial & Dob Starfinders

Meade SCT & Maks 3.5"-16"

8"LX10 w/wedge, hand controller ($65)	$995
Field Tripod for 8" LX10 ($20 P&S)	$195
8" LX50 w/wedge ($115 P&S)	$1395
Adj. tripod for 8-10" SCT ($30 P&S)	$295
8" LX200 w/computer ($105 P&S)	$2795
Wedge for photographing w/8" LX200	$139
7" LX50 f/15 Maksutov w/wedge ($125 P&S)	$1795
10" LX50 f/10 w/wedge, dec. motor, hand controller ($155 P&S)	$1695
10" LX 200 w/ computer ($155 P&S)	$3195
12" LX 200 (f/10 only) ($215 P&S)	$4495
SuperWedge for photo. w/10", 12" LX200	$395
16" LX200 f/10 w/tripod ($385 P&S)	$14,950

LX50 – includes dec. motor, hand controller.
LX 200 - full computer control w/64k mem.
Tripod: Extra for LX 50; included for LX200

Note: Wedge is not needed for visual observing with the LX 200. Select f/10 or f/6.3 (no extra charge) for LX 200.

Meade Dobsonians 6 -16"

6"f/8 Dobsonian Starfinder ($46P&S)	$349
6"f/8 Equatorial Starfinder ($79 P&S)	$649
8"f/6 Dobsonian Starfinder ($59P&S)	$449
8"f/6 Equatorial Starfinder ($89 P&S)	$749
10"f/4.5 Dobsonian Starfinder ($85P&S)	$599
10"f/4.5 Equatorial Starfinder ($99 P&S)	$879
12.5"f/4.8 Dobsonian Starfinder ($95P&S)	$895
16"f/4.5 Dobsonian Starfinder (frt. COD)	$1195
16"f/4.5 Equatorial Starfinder (frt. COD)	$2695

*All Starfinder telescopes shipped directly from Meade to the purchaser. Please add the indicated packing and shipping charge to the price. Slightly lower P&S for payment by check. Lumicon showroom prices are $50 to $100 higher.

See the Meade ad in this magazine for full descriptions. Starfinders are complete telescope systems with motor drive and finderscope (Equatorial only) and 25mm (48x) eyepiece. New DC motor runs on four AA batteries.

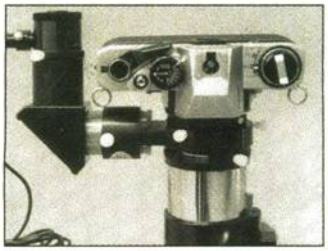
PENTAX EYEPIECES

Great Prices ! Pentax 65° XL

Amazing performance! All have 20mm eye relief, adjustable helical eye guard, super multi-coatings, E.D. Glass

5.2mmF.L., 65°Apparent Field 1 1/4"	$279
7mm F.L., 65° Apparent Field 1 1/4"	$279
10.5mmF.L., 65°Apparent Field 1 1/4"	$269
14mm F.L., 65° Apparent Field 1 1/4"	$269
21mmF.L., 65°Apparent Field 1 1/4"	$269
28mm F.L., 55° Apparent Field 1 1/4"	$259
40mmF.L., 65°Apparent Field 2"	$299

3 Choices of our Lumicon Easy Guiders ™



Newtonian Easy-Guider ™

The **LUMICON NEWTONIAN EASY-GUIDER ™** is the best choice on the market for guiding both Newtonian and Refractor telescopes. Off-axis guiding is the surest way to get pin-point star images. The two-way adjustment on the off-axis tube avoids the problems of finding and centering a guide star in your eyepiece or autoguider. A 35mm camera adapter is included (specify camera). Available for either 1.25" or 2" focusers at ....**$189.50 each**

Cassegrain Easy Guider™

For 8" Schmidt-Cassegrain telescopes choose the **LUMICON CASSEGRAIN EASY GUIDER™.** Includes mutiple adjustments for easily finding and centering a guide star and for composing the picture. The included internal 50mm focal reducing lens delivers brighter f/6 photographic images and can be used visually with an optional adapter. The lens can be removed for f/10 photography. A 35mm camera adapter (specify camera) is included....**$249**
Visual Adapter **$25**

Lumicon Giant Easy Guider™

The king of off axis guiders is the **LUMICON GIANT EASY GUIDER™.** Made for Schmidt-Cassegrain telescopes of 10" through 16" diameter, the giant easy guider attaches to the large 3" rear threads of these scopes. Included is an 80mm diameter focal reducing lens capable of delivering f/7 to f/4 photographic speed. Replacing the included 35mm camera adapter (specify camera) with a 2" star diagonal turns the giant easy guider into a full aperture rich-field viewer......................................**$395**
1 1/4" viewing adapter for rich-field..**$25**

Meade & Celestron

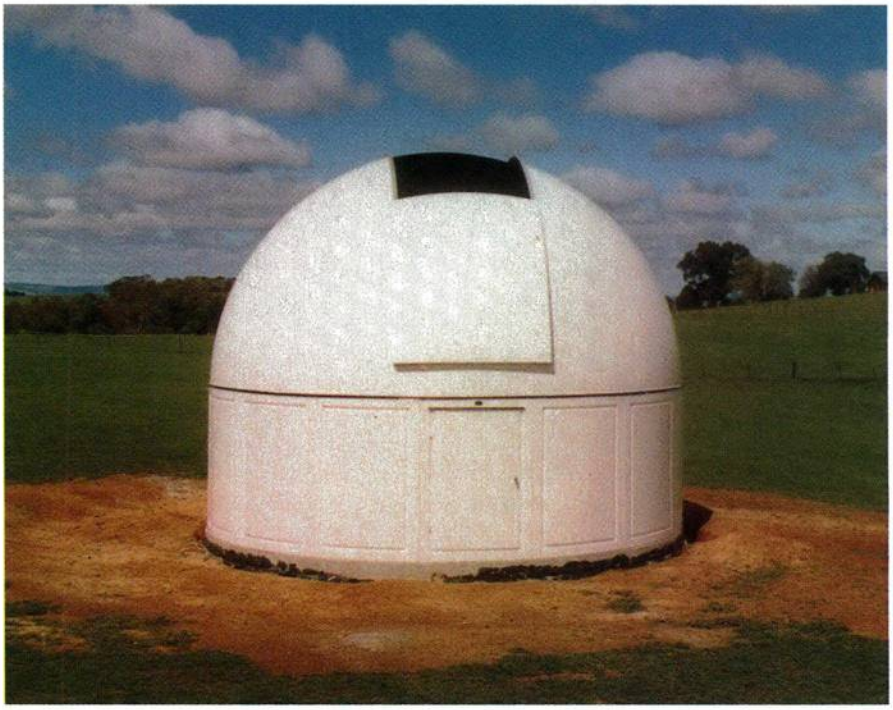
Lumicon carries a full line of
Meade & Celestron Telescopes & Accessories
All at competitive prices & with FAST delivery
California residents add 8.25% sales tax

PRODUCTS

Boyd's New Dome

▶ Garry Boyd has added a 22-foot dome to his line of backyard observatories. Its fiberglass construction is designed to house large-aperture telescopes. Features such as two doors, handicap accessibility, and illuminated exit signs make opening the dome to the public easy. Inside, a full 22-feet of floor space is available with the dome's apex more than 18 feet high. Both the rotation and slit operation are electronically controlled for easy observing. The power source is solar and includes an auxiliary 20 amp AC charger for those days clouds blanket the sky.

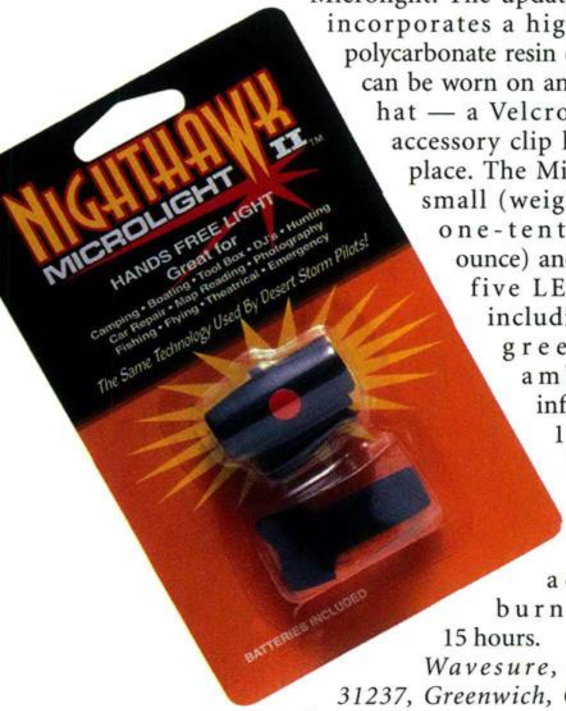
Boyd Observatories, 57607 Broughton Road, Ray, MI 48096; phone, (810) 749-9525; e-mail, gjboyd@tir.com; website, www.boydobservatories.com. Model 22.0 Astronomical Observatory : *$48,000*



Night Light

▶ Looking for a compact light to read star charts by? Wavesure has redesigned its Nighthawk Microlight. The updated version incorporates a high-impact polycarbonate resin design that can be worn on any finger or hat — a Velcro strap or accessory clip keeps it in place. The Microlight is small (weighing only one-tenth of an ounce) and comes in five LED colors including white, green, red, amber, and infrared. Two 1.5-volt button batteries power it, yielding a continuous burn time of 15 hours.

Wavesure, P.O. Box 31237, Greenwich, CT 06831; phone, (888) 650-3345; e-mail, info@wavesure.com; website, www.wavesure.com. Nighthawk Microlight II: *prices start at $17.99.*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The Same Technology Used By Desert Storm Pilots!
BATTERIES INCLUDED

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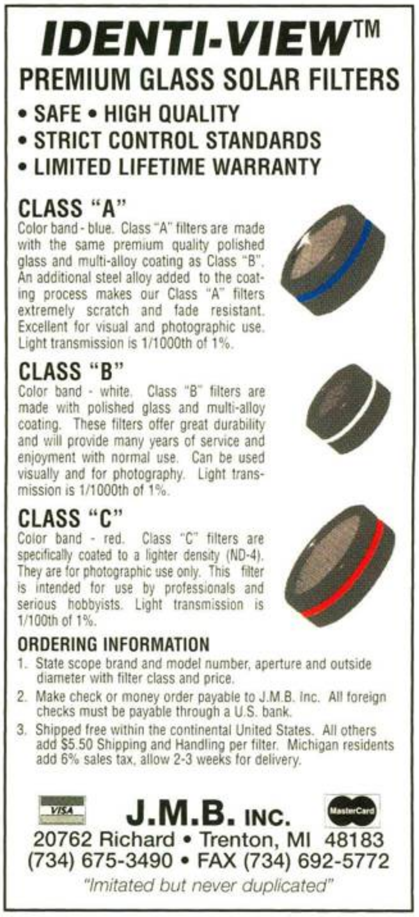

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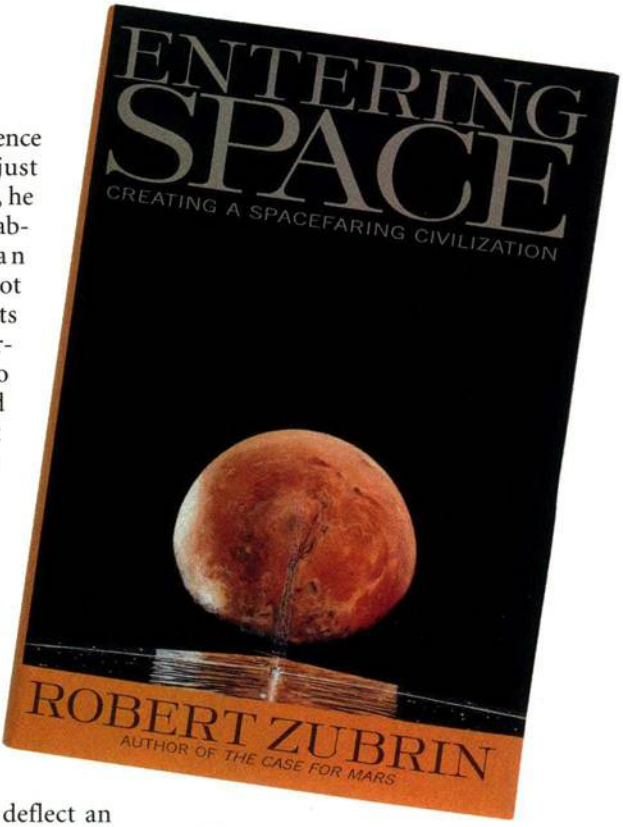
BOOKS

Entering Space: Creating a Spacefaring Civilization

Robert Zubrin, 305 pages, Jeremy P. Tarcher/Putnam, New York, 1999; ISBN 0-87477-975-8; hardcover, $24.95.


ENTERING SPACE
CREATING A SPACEFARING CIVILIZATION
ROBERT ZUBRIN
AUTHOR OF THE CASE FOR MARS

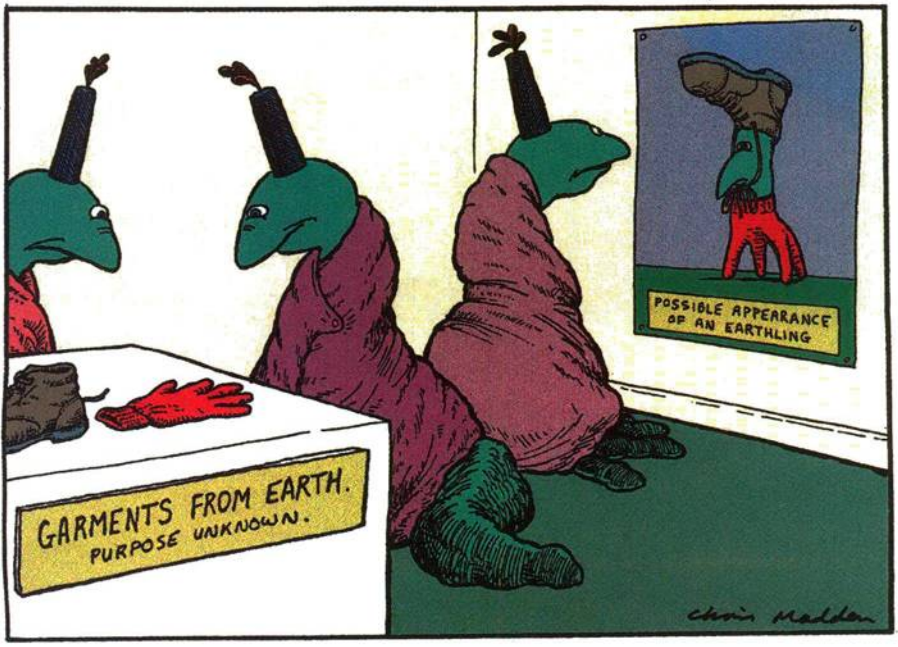
▶ Make no mistake; Robert Zubrin knows his rocketry. He is the founder of the Mars Society and author of *The Case for Mars*, a detailed guidebook on how humans could realistically colonize Mars in the next few decades. But Zubrin is more than just a writer and an engineer. He is also an entrepreneur who founded two aerospace companies, both of which work to advance space technology. In his new book, *Entering Space*, Zubrin details exactly how humans can achieve a permanent presence in space, both near Earth and just about as far away as we can get from it.

Borrowing from Soviet astrophysicist Nikolai S. Kardashev, Zubrin categorizes advanced civilizations into three levels: A Type I society has mastered the resources of a planet; a Type II society controls its planetary system; and a Type III civilization has access to an entire galaxy. According to Zubrin, we are in the final stages of Type I and preparing for Type II (I disagree with this assessment — our mastery of the planet is debatable). This book purports to be our guide to becoming a Type II civilization.

This might sound like science fiction, but Zubrin shows just how it could work. Better yet, he shows us why we need to establish a permanent human presence in space. He does not simply accept old arguments about the necessity of exploring space, such as the need to manufacture materials and drugs in microgravity, but explains in detail what we can do once we get there.

Zubrin uses asteroids as an example. These space rocks represent both enormous danger and potential wealth for a Type II civilization. The danger is obvious: A large impact could wipe out life on a planetary scale. We need to know more about asteroids in order to deflect an approaching one away from Earth. The wealth isn't hard to envision either; asteroids represent a king's ransom in minerals and scientific knowledge.

Zubrin details how much it would cost to build and launch a craft to a near-Earth asteroid, including a list of necessary provisions (food, fuel, equipment, and even furniture). His proposed spacecraft carries a crew of four and a solar-flare shelter and would even spin to provide ersatz gravity for the crew's health. The astronauts would explore the asteroid and return home with samples for scientific analysis. It's a well-thought-out plan, and one earthlings might be able to implement early in the next century.


POSSIBLE APPEARANCE OF AN EARTHLING
GARMENTS FROM EARTH.
PURPOSE UNKNOWN.
Chris Madden

Chris Madden

Entering Space discusses the need for colonies on asteroids, the moons of the outer planets, and of course Mars. Zubrin argues that we need Mars more than the moon because Mars is closer to the asteroid belt, so it can serve as a way station to the resources of the outer solar system. Mars also has many resources that the moon lacks, such as chemicals in the rocks and atmosphere that can be converted to breathable air, fuel, and machine parts.

And Zubrin doesn't stop there. Once we have tamed the solar system with nuclear-powered rockets, our descendants could develop far more advanced technologies, including solar sails, antimatter engines, Dyson spheres, and even black holes for accelerating interstellar probes to 0.5 percent the speed of light.

Although Zubrin shines brightly when discussing engineering, I found a few of his philosophical arguments to be weak. For example, he argues that a civilization that doesn't expand

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Things seem to be going great for Roger and the business. "We're quite happy with **Astronomy** as well," he added. "The service from all departments has always been great, and I've never had any problems. **Astronomy** Magazine has certainly contributed quite a bit to our business!"

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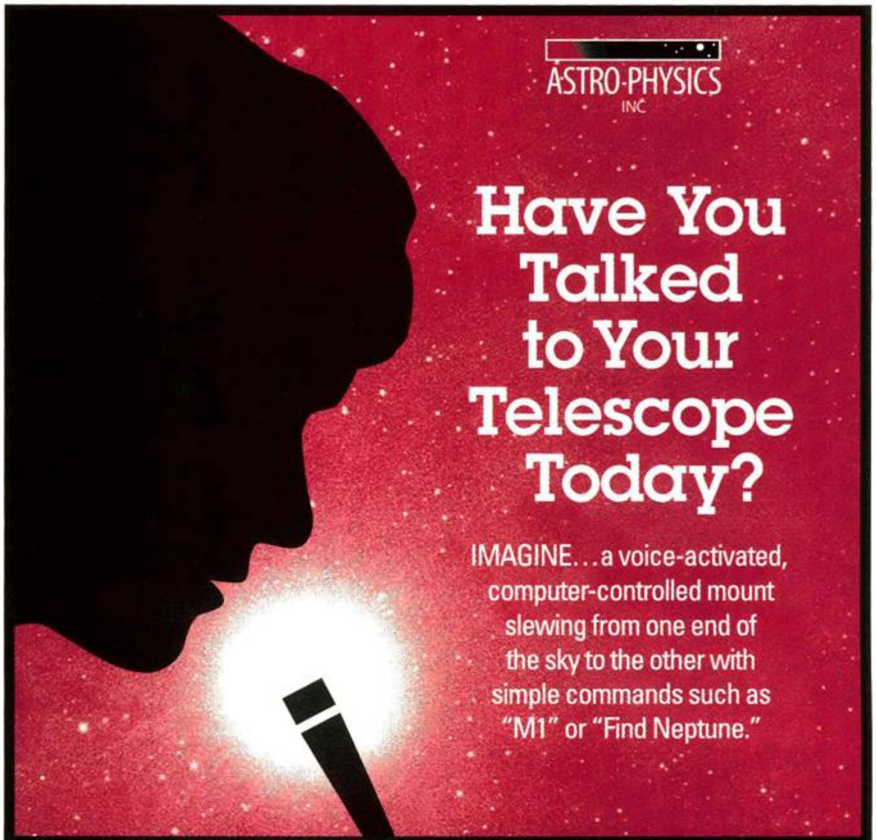
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stagnates and that future expansion must occur in space because there is nowhere else to expand. I think this is a broad and not necessarily accurate generalization. Other physical frontiers besides space exist, such as the deep ocean. And other frontiers besides the physical await. There will be plenty of challenges left to overcome by the people on Earth. His argument about stagnation has some merit (after all, many young, vigorous civilizations on Earth have been expansionist), but it needs to be developed further if it is to become a compelling justification for colonizing space.

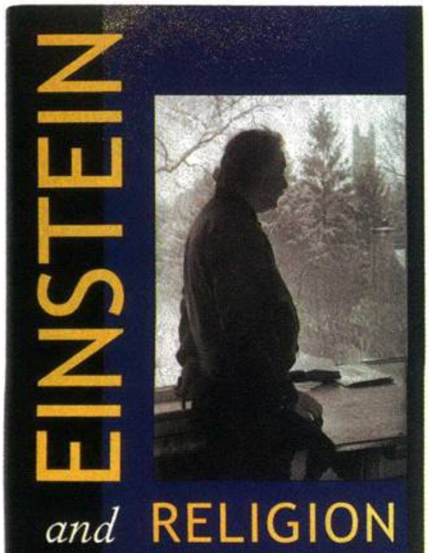
While some aspects of Zubrin's case may be suspect, others are quite valid, and his technical arguments are sound. The philosophical weak points do not detract from his solid engineering discussions. This book offers an involving read, and it will make its readers think more critically about space exploration and its ramifications for our future. — *Phil Plait, Advanced Computer Concepts, Inc. (www.badastronomy.com)*

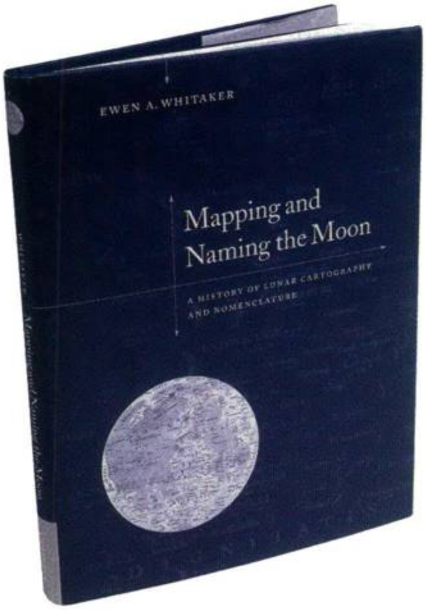
Einstein and Religion

Max Jammer, 279 pages, Princeton University Press, Princeton, New Jersey, 1999; ISBN 0-691-00699-7; cloth, $22.95.

▶ Nobody disputes that Albert Einstein was a genius, and the public perceives him to be nearly omnipotent in the field of physics. Because he had such impressive intellectual abilities that could reveal secrets of the universe, many people have been interested in learning about Einstein's personal views of religion. *Einstein and Religion* attempts to shed light on Einstein's beliefs in an unbiased manner.

The book is divided into three chapters, one on the role of religion in his private life, one on his philosophy of religion, and one on how his physics combines with theology. Physicist Max Jammer spends a good deal of time analyzing the famous Einsteinian quote, "Science without religion is lame, religion without science is blind." For ardent fans of Einstein, this work provides a fascinating look into Einstein's private thoughts.




EWEN A. WHITAKER
Mapping and Naming the Moon
A HISTORY OF LUNAR CARTOGRAPHY AND NOMENCLATURE

Mapping and Naming the Moon: A History of Lunar Cartography and Nomenclature

Ewen A. Whitaker, 242 pages, Cambridge University Press, New York, 1999; ISBN 0-521-62248-4; hardcover, $59.95.

▶ In this scholarly yet accessible book, astronomer Ewen A. Whitaker details the origin and evolution of the modern-day system for naming lunar craters and other features. This authoritative and richly illustrated volume contains numerous historic photos, drawings, and maps. The text wonderfully highlights the connection between the past and present. If you're a moon buff, this book is right up your alley.

PRODUCT INFO

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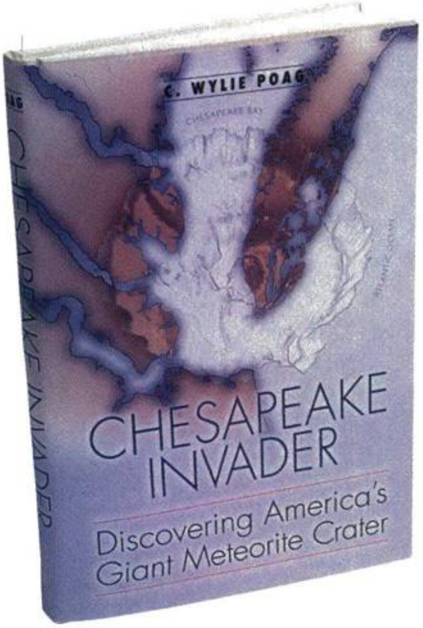
Chesapeake Invader

Wylie Poag, 183 pages, Princeton University Press, Princeton, New Jersey, 1999; ISBN 0-691-00919-8; hardcover, $24.95.

▶ Thirty-five million years ago, a meteorite three miles wide and moving 60 times faster than a bullet slammed into the seabed near what is now Chesapeake Bay. The impact, more powerful than the combined explosion of every nuclear bomb on Earth, blasted a crater 50 miles wide and one mile deep. Shock waves radiated for thousands of miles, shaking the Appalachians. Gigantic waves and winds of white-hot debris transformed the eastern seaboard into a lifeless wasteland. Wylie Poag, a senior scientist with the U.S. Geological Survey, reconstructs the events of this catastrophe and explains how scientists unearthed evidence of the impact.



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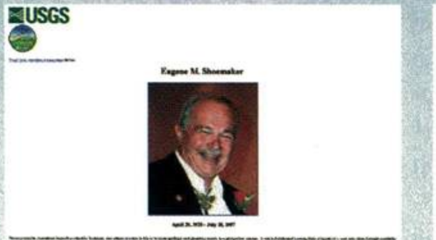
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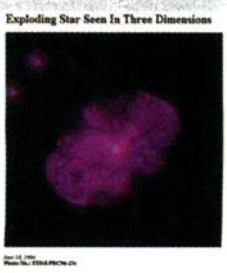
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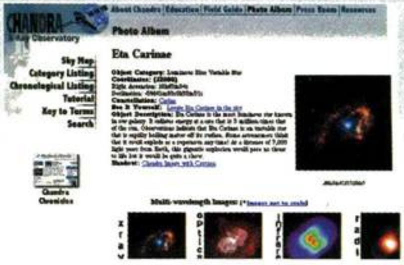
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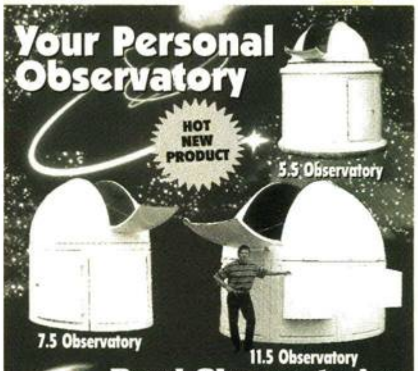

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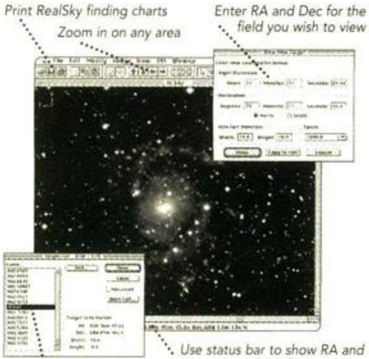
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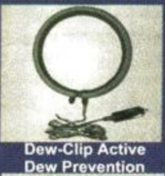
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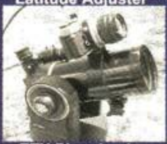
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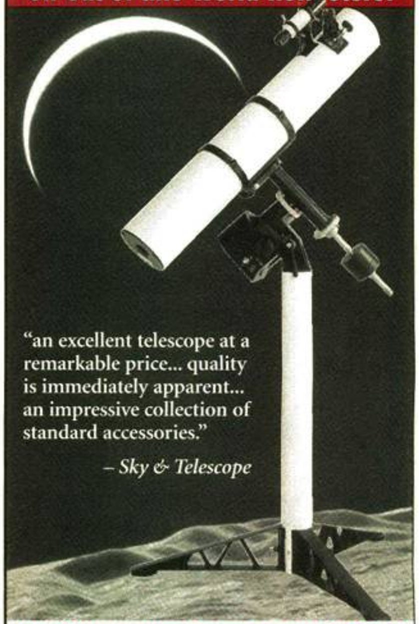

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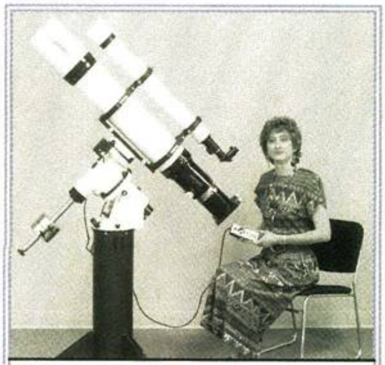

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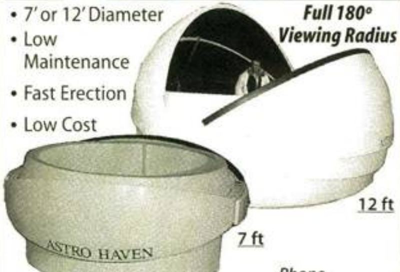

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▶ Camp Wesumkee, West Summerland Key, Florida Keys. Sponsored by the Southern Cross Astronomical Society. For information, contact registrars Fred and Lucille Heinrich, 6165 Wiggins Road, Live Oak, FL 32060; (904) 362–5995; fax, (904) 362–5996; e-mail, Heinrich@alltel.net; website, www.scas.org. For hotel information, call 1–800–FLA–KEYS.

FEBRUARY 2–6

Orange Blossom Special Star Party

▶ Hickory Hill Observing Complex, near Brooksville, Florida. Sponsored by the St. Petersburg Astronomy Club. Contact Dennis and Ellen Farr, 8811 West Broad Street, Tampa, FL 33615; (813) 884–9111; e-mail, dnefarr@aol.com.

FEBRUARY 12

Wagman Winterfest

▶ Nicholas Wagman Observatory, Deer Lakes Park, Russellton, Pennsylvania. Free. Sponsored by the Amateur Astronomers of Pittsburgh. Contact Pete Zapadka, 186 Sheldon Avenue, Pittsburgh, PA 15220-2637; (412) 279–0627; e-mail, pzapadka@fyi.net; website, http://www.fyi.net/~pzapadka/wfest.html.

MARCH 2–5

Highlands Stargaze

▶ Nine Mile Grade Campground, Highlands County, Florida. Daytime events include a swap meet, speakers, vendors, a free barbeque, and door prizes. Sponsored by the Highlands Stargazers Astronomy Group. Contact Richard Lindblom, (941) 655–0131; e-mail, lindblom@ct.net; website, http://www.cris.com/~Suz1/Index.shtml.

MARCH 13–17

Lunar and Planetary Science Conference

▶ The NASA Johnson Space Center, Houston, Texas. The meeting will focus on new results in planetary science among researchers in astronomy, geology, geophysics, geochemistry, and petrology. Contact LeBecca Simmons, LPI Publications and Program Services Department, 3600 Bay Area Boulevard, Houston, TX 77058; (281) 486–2158; e-mail, simmons@lpi.jsc.nasa.gov.

MARCH 31–APRIL 2

Telescope Optics Workshop

▶ Bellingham, Washington. For more information, contact Kreig McBride, 402 East Horton Road, Bellingham, WA 98226; e-mail, kmcbride@memes.com; website, http://www.wwu.edu/~skywise/optics.html.

APRIL 6–9

Peach State Star Gaze

▶ Camp McIntosh, Indian Springs State Park, Georgia. Featuring Antonin Rukl of Prague, Czech Republic, author of *Atlas of the Moon*. Preregistration is required. Contact Ken Poshedly, 1741 Bruckner Court, Snellville, GA 30078; (770) 979–9842; e-mail, ken.poshedly@mindspring.com; website, http://aac.cjb.net.

CONTACT

Please submit club announcements four months in advance to Looking Ahead, *Astronomy*, P.O. Box 1612, Waukesha, WI 53187-1612, or to tconley@astronomy.com. Look for additional events at http://www.astronomy.com.

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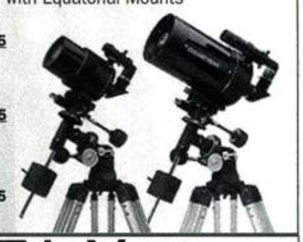

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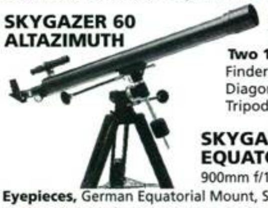

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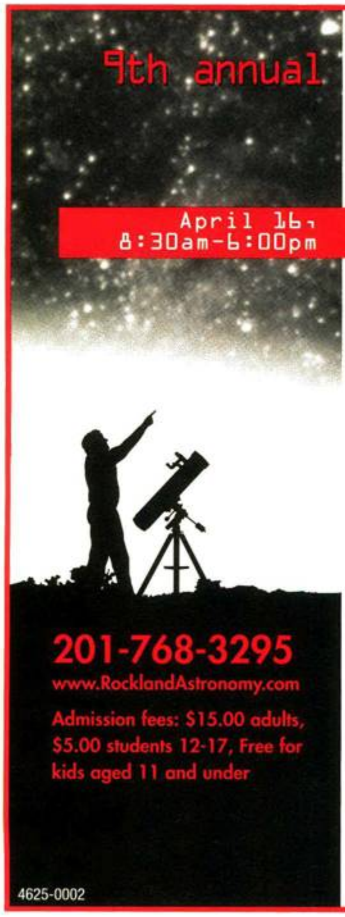

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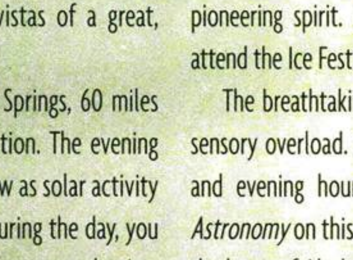
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THE NORTH STAR

Minding the Gap

▶ One Sunday night, I was out at a park doing some solo observing. I had my refractor set up at one end of the parking lot next to the SUV, the folding table, and the usual stuff. About 10 P.M., a car drove up and parked some distance away. I heard muted voices for half an hour but didn't pay much attention. Finally, a kid maybe 16 or 17 years old came over. We shook hands, introduced ourselves, and struck up a conversation.

"What are you doing?"

"I'm just out doing some observ—"

"Wow, I've never seen a telescope that big before!"

"It's a 6-inch—"

"I bet you could see into the future with that!"

"Actually, you are really seeing into the pa—"

"Do you think there is life on other planets?"

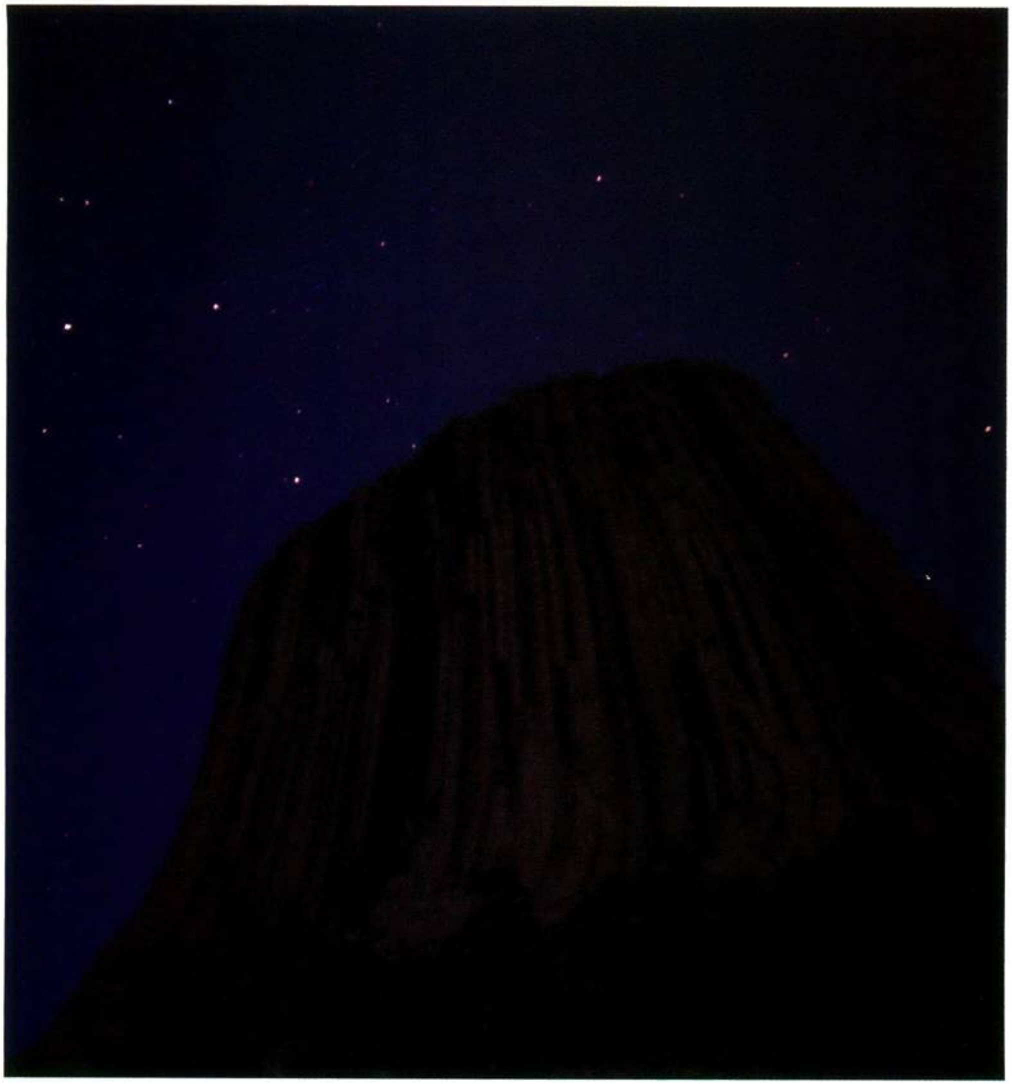
"I don't think—"

"Did you ever see any aliens?"

Hoping that the last comment was a joke, at this point I realized that I wasn't going to be able to carry on a conversation where both parties actually get to finish a sentence. So I asked him if he wanted to take a look through the telescope. He wholeheartedly agreed and was at the eyepiece in a flash. I had it on the Orion Nebula, and I attempted to explain what he was looking at. I tried to say it fast. I figured if I didn't, I wouldn't get it out. I was right.

"Do you see those four sta—"

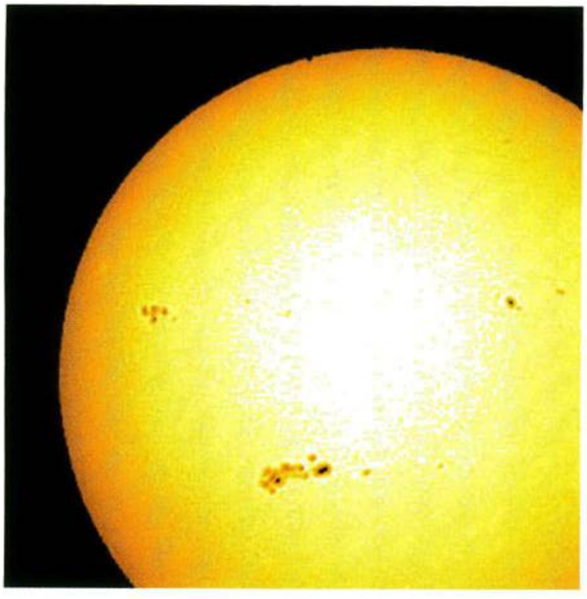
"Hey, there's four stars in the middle of that cloud!"



Close Encounter of Devil's Tower and Northern Cross

RANDALL WEHLER

(28mm lens at f/2.8, Kodak 1600 ISO film)



Sunspots Dwarf Mercury

DOUG MURRAY

(9-inch SCT at f/10, Fuji Provia 100F RDP III slide film, 1/125-second exposure taken November 15, 1999)

"That cloud is actu—"
"What is that?"
"It'sanimmensecloudofgasinwhichstarsareforming!"

The conversation went on like this for about five minutes. Then he asked if it would be okay if his friend could come over as well. "Sure," I said, even though I had reservations. He then walked back to the car to get his friend, who, fortunately, came over by himself.

His buddy looked the same age but was about 6'2" and 180 pounds. He walked up smiling, we shook hands and introduced ourselves, and, in the words of Yogi Berra, it was déjà vu all over again.

"What are you doing?"

"I'm just out doing some observ—"

"Wow, I've never seen a telescope that big before!"

"It's a 6-inch—"

"I bet you could see into the future with that!"

"Actually, you are really seeing into the pa—"

"Do you think there is life on other planets?"

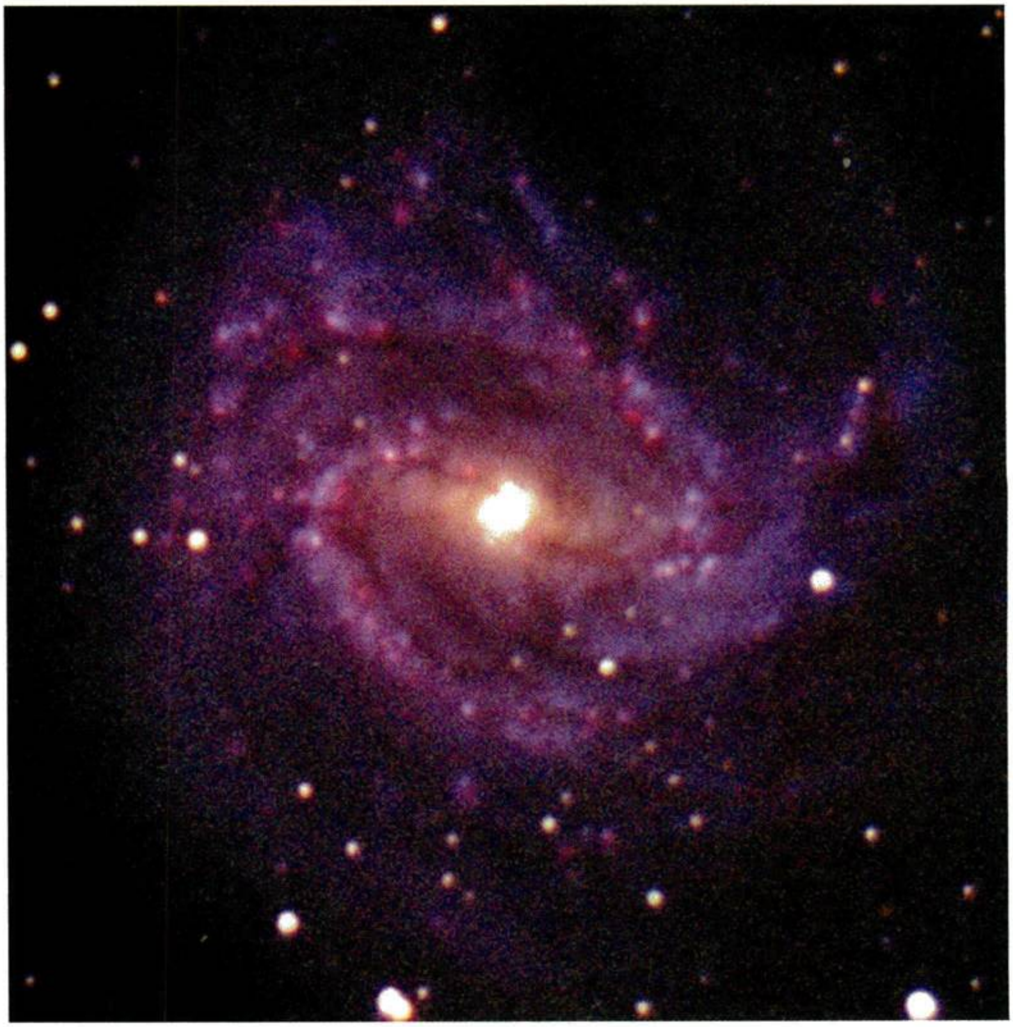
"I don't think—"

"Did you ev—"

"Ineversawanyaliens!"

At about this time the first kid came back and asked if it would be okay if his girlfriend could come over and look through the scope too. "Sure," I said and began to sweat.

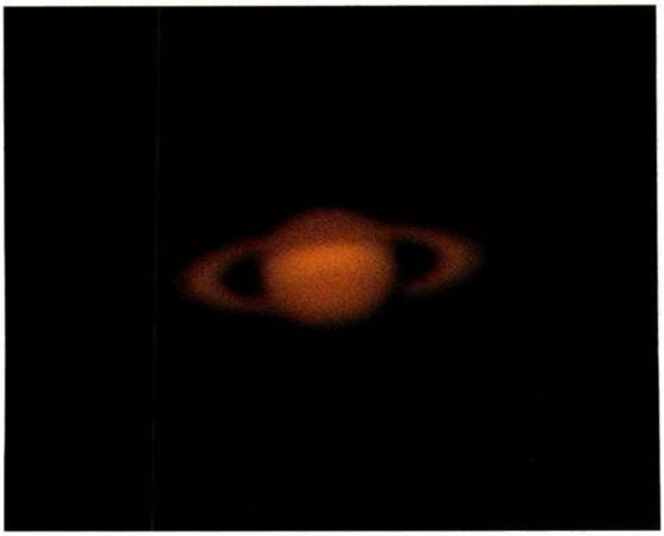
I was relieved when she came over and introduced herself. About sixteen, she was very well mannered and *didn't* ask what I was doing. She was reserved but expressed interest in looking through the scope. I showed her Orion and a couple other objects. She enjoyed it. We talked for a bit, with me all the while trying to provide what I thought was the appropriate (read *quick*) answers to any questions.



Galaxy M83

JASON WARE

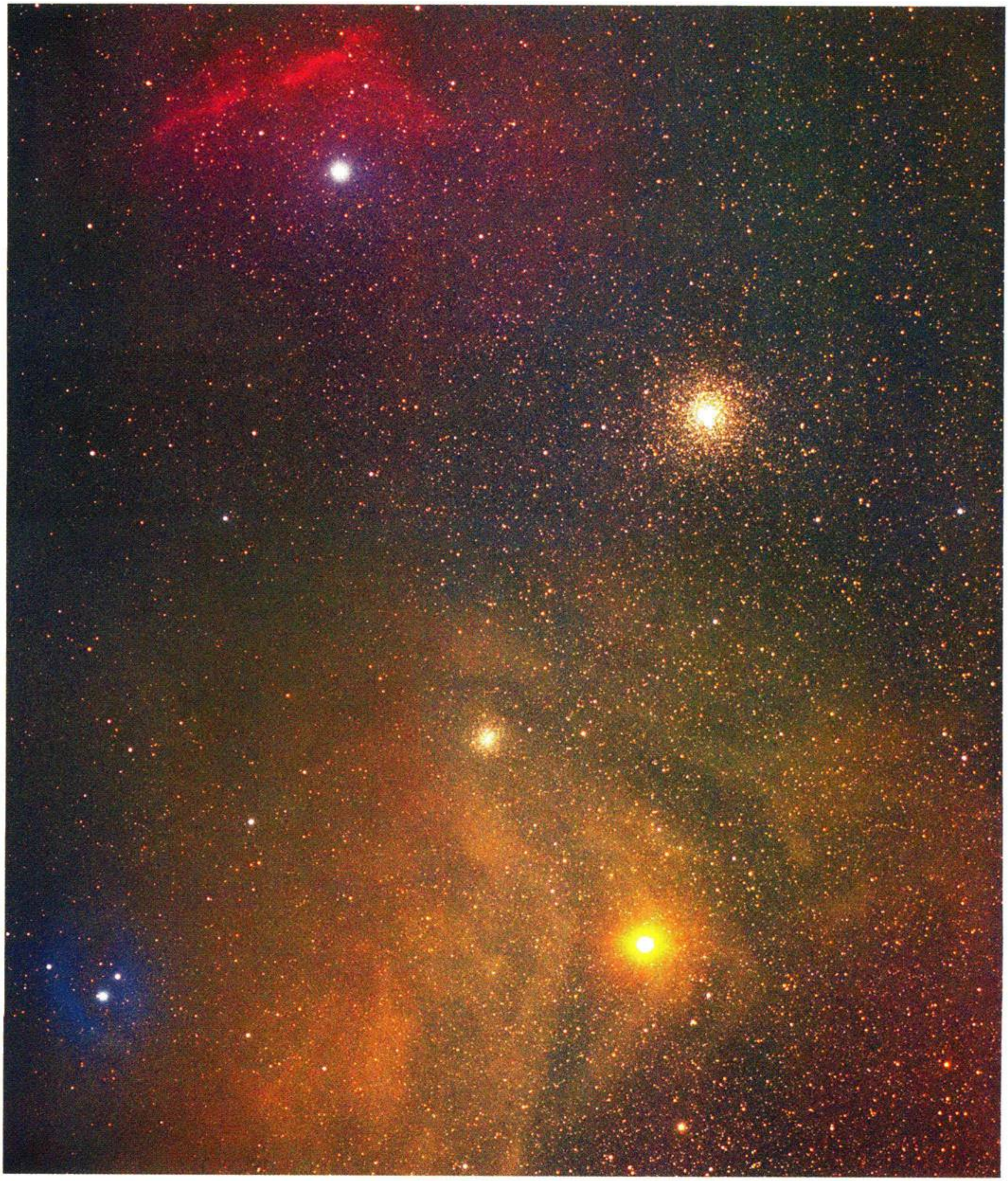
(16-inch SCT at f/10, hypered Kodak PPF 400 120 format film, composite of two 45-minute exposures)



Suspended Saturn

HOWIE GLATTER

(5-inch refractor at f/22, Fuji 800 film, 4-second exposure taken September 19, 1998)



The Colors of the Rho Ophiuchi Region

ALLEN HWANG

(6-inch f/7 refractor, PPF 120 format film, composite of two 60-minute exposures)

At one point, one of the guys asked how I knew where to look for objects in the sky. So I said, "You start with the North Star and—"

"What's the North Star?"

At first I was taken aback. When I realized this was an honest question, it pretty much floored me. These kids were obviously curious, interested, and bright, yet the North Star was a brand-new concept. I'd figured learning the North Star must come up at some point early on, surely by junior prom time. I gave it my best shot, but I don't know how much sank in. After a while they had to go and we bid goodbye.

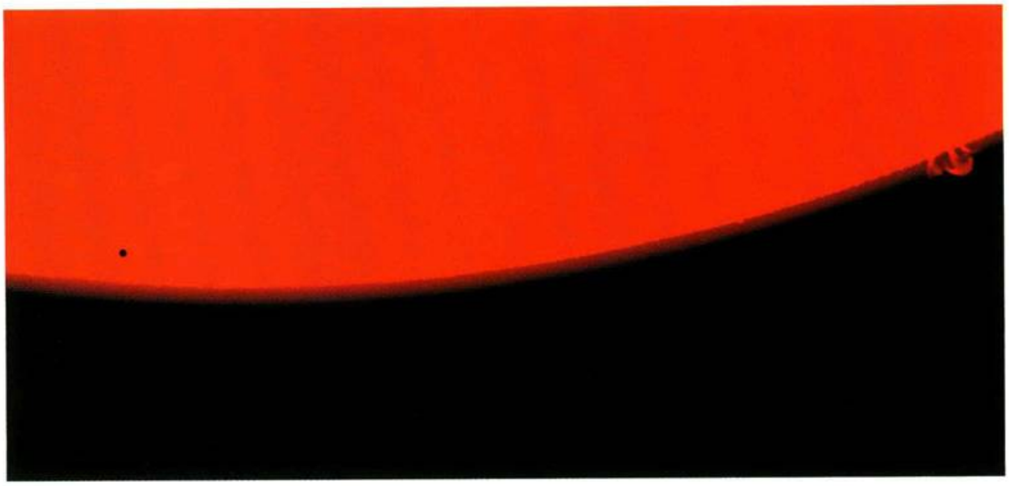
This chance meeting has stayed with me. I get the impression that the lack of knowledge about something as basic as the North Star relates in part to the current overwhelming bombardment by useless information. Kids today get 60 TV channels to choose from, and shows such as those on MTV deliver information in staccato-like fashion. When I was 16 (seemingly ages ago), music on TV came via prime-time variety shows. (Imagine Perry Como in split-second flashes!)

Maybe I'm making too much of this. Maybe I should chalk it up to a generation gap. Then again, we may only have had three TV channels when I was a kid, but I did get to learn what the North Star was.

Remember Como's TV theme song? *"Dream along with me, I'm on my way to the stars...."*

Sing it, Perry. Slow and sweet.

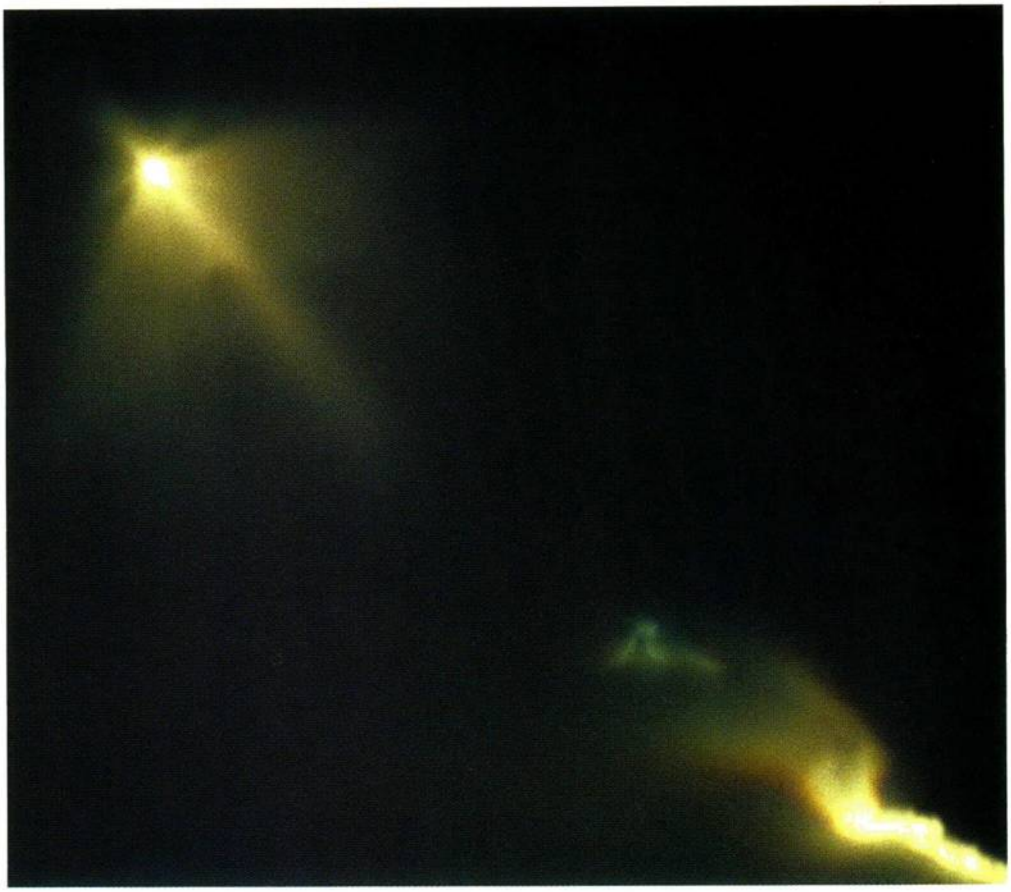
Mike Turco is an engineering manager living in Thornton, Pennsylvania.



Mercury Transits the Sun

DAVID CORTNER

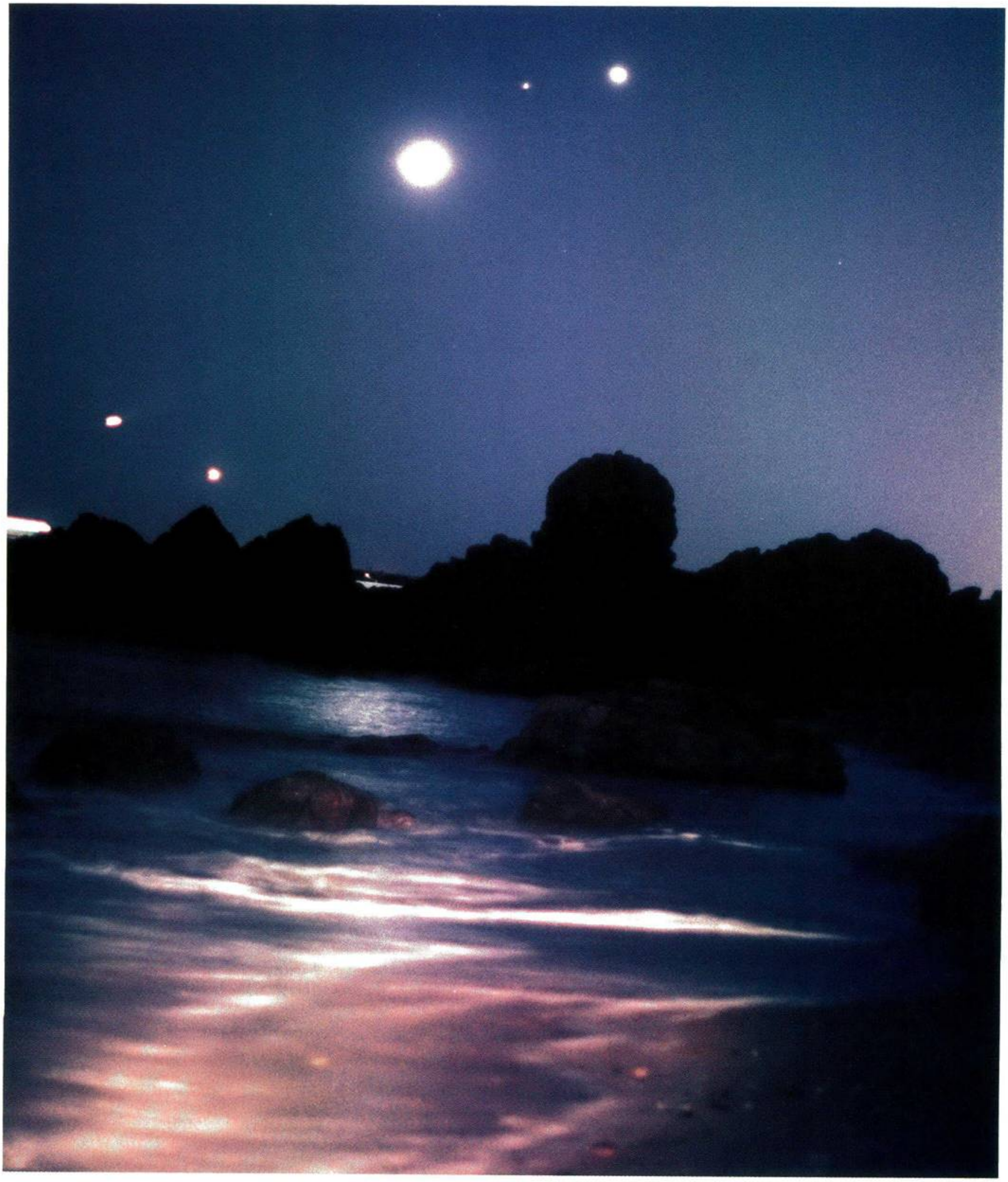
(5-inch refractor at f/27, Hα filter, taken November 15, 1999)



Minuteman II Second Stage Separation

MICHAEL STECKER

(135mm lens, Kodak Royal Gold 400 film, taken October 2, 1999)

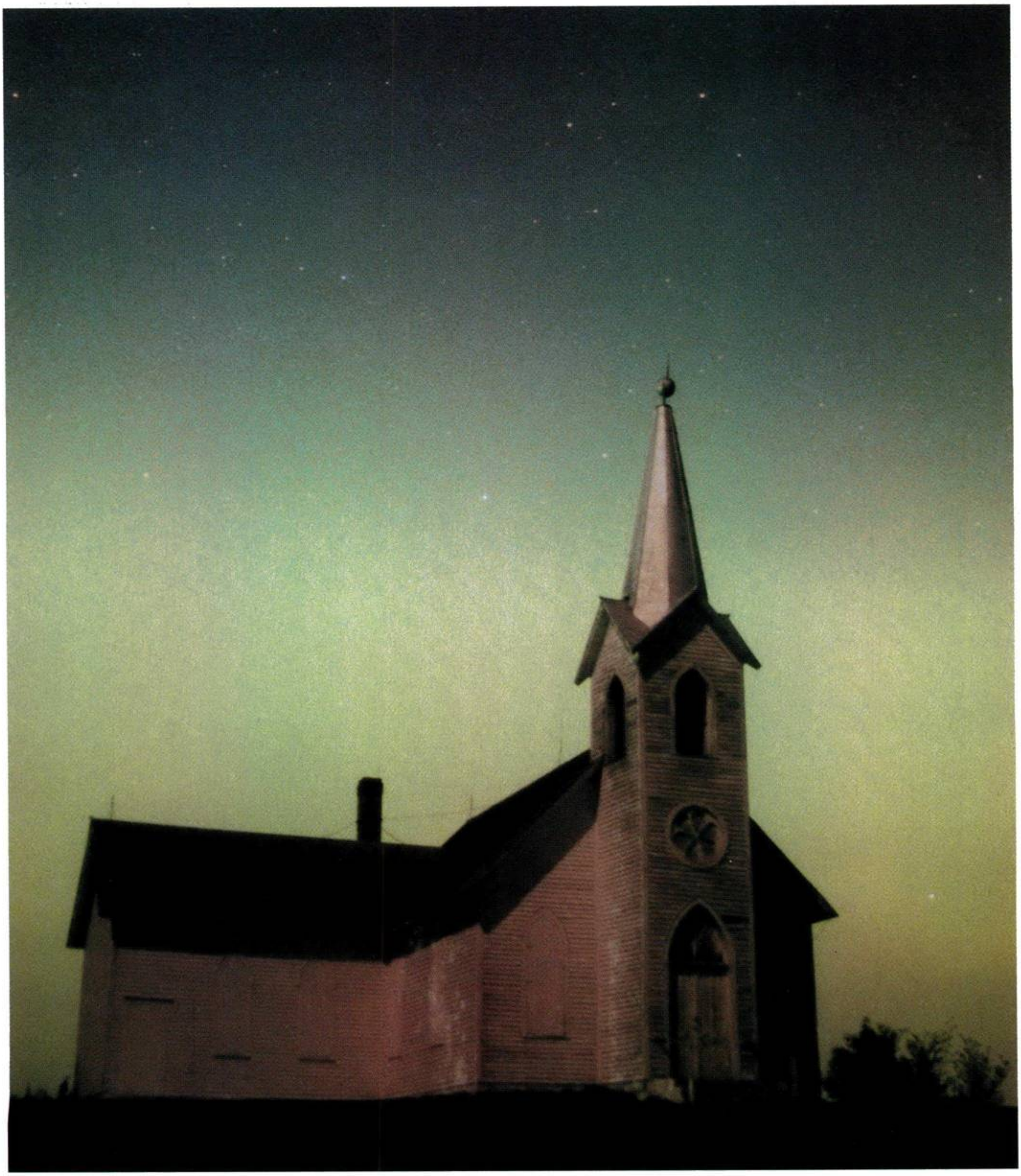


Laguna Triangle (Moon, Saturn, and Venus)

WALTER PACHOLKA

(taken March 19, 1999)

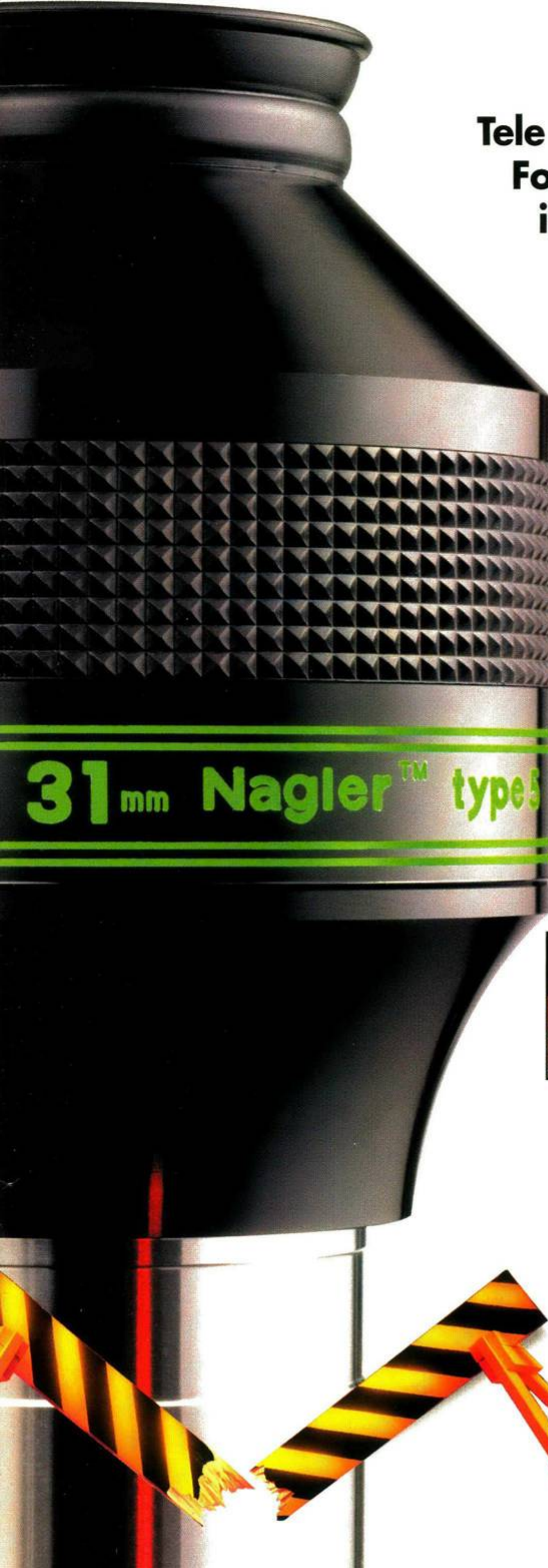
This month's best astrophoto



Northern Lights Awaken the Night

RANDALL WEHLER

(28mm lens at f/2.8, Fuji 800 Super G plus film, 30-second exposure taken May 3, 1998)
Green, as seen in this image of a country church in Minnesota, is the most common auroral color.



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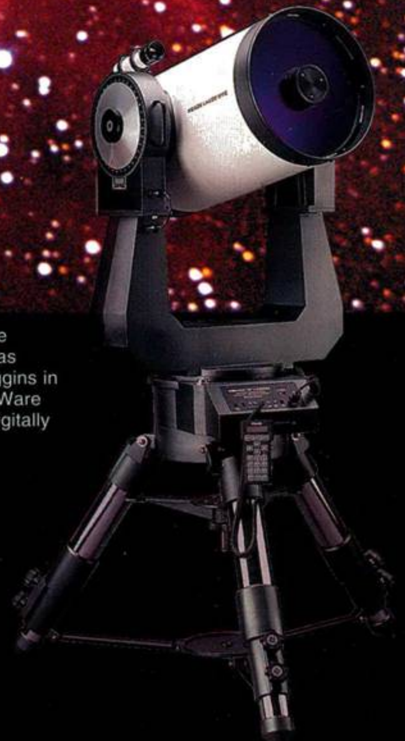
Located near the northern border of Sagittarius, the Swan (or Omega) Nebula is one of the most prominent of the diffuse nebulae. Discovered by Charles Messier in 1764 and placed into his catalog as its seventeenth object, the Swan Nebula was determined spectroscopically to be a mass of glowing gas, and not simply an unresolved cluster of stars, by Sir William Huggins in 1866. This image, one of the most detailed ever obtained of M17 with any telescope, amateur or professional, is by Jason Ware with a Meade 16" LX200 Schmidt-Cassegrain. Two 60-minute exposures on hypered Kodak PPF 400 film were scanned, digitally combined, and processed to obtain the final image shown here.



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